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Rubber tires and all about them

Henry Clemens Pearson

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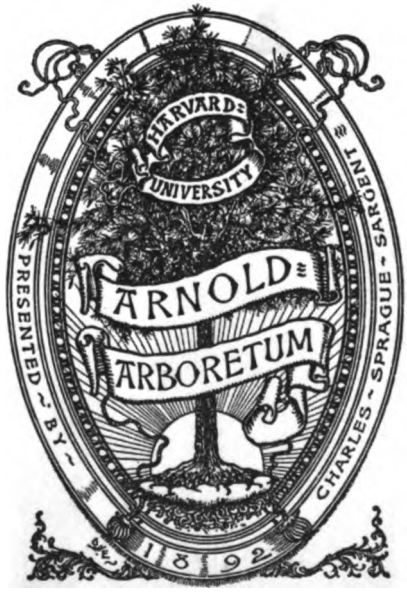

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RUBBER TIRES AND ALL ABOUT THEM

Pneumatic, Solid, Cushion, Combination, For Automobiles, Omnibuses, Cycles, and Vehicles of Every Description

---

By HENRY C. PEARSON
Editor of *The India Rubber World*

NEW YORK
THE INDIA RUBBER PUBLISHING COMPANY
35 West 21st Street
1906

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June 1910
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FOREWORD.

THE hardest problem that ever confronted the rubber trade was the production of a tire that would hold air, in other words, the pneumatic. It was, however, successfully solved. The bicycle and later the automobile, resulted from it, and a new industry in rubber was created. Thousands of men and millions of dollars are employed, while as a gage of the world's interest in the subject, may be taken the thousands of patents that are granted annually for tires, rims, tools, and accessories to tires. Touching the same field, and serving the same purpose, to a degree, is the solid tire. For light and heavy vehicles of all sorts it is today a necessity, and around it has grown a business second only in importance to the pneumatic tire.

This is in no sense a technical work designed to show the rubber manufacturers how to make tires, else it would contain compounds, heats, and detailed descriptions of processes. As a matter of fact, those in the field today need no such information, for they are as well equipped to solve their problems as any manufacturing body in the world. It is prepared for the great number of persons whose interest in tires comes from their handling, repairing, and using them. It is in a word, a simple dictionary of what has been done in tires and their accessories.

Much has been written about tires, but as a rule the information has been meager and oftentimes misleading, the reason being that the writers did not know rubber and could not grasp the subject intelligently. That the writer of this volume has done better or worse than others is proved or disproved in these pages. At all events he is a practical rubber man, has made tires, and has studied the subject in the leading tire factories in the United States and Europe. In addition to this, as publisher and editor of The India Rubber World, he is in a position to secure a large amount of material relative to tires not accessible even to the most progressive tire manufacturers. He therefore presents this book with confidence that somewhere in its pages will be found matter of value to all who are in any way interested in rubber tires—a subject whose past history has revolutionized the methods of travel and whose future holds almost inexhaustible possibilities.

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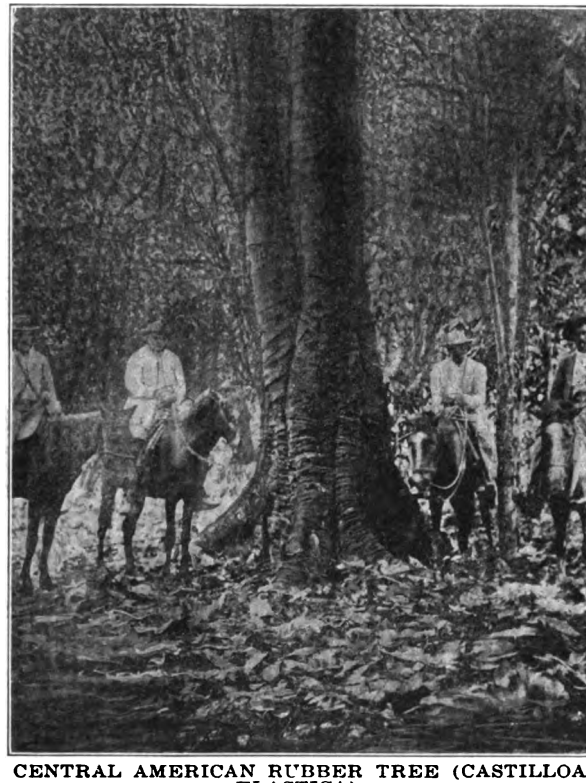
CHAPTER I.

WHAT INDIA-RUBBER IS.

THERE is perhaps no substance used in the arts today about which so little is known to the layman as india-rubber. How well I recall an occasion when the subject of gum elastic came up for discussion, and turning to a well known wit, I said:



CENTRAL AMERICAN RUBBER TREE (CASTILLOA ELASTICA).

"Mr. ———, what is rubber?"

After a pause he replied, with a smile:

"Rubber—'to turn and gaze intently'—is a verb. When it precedes a noun, such as 'neck,' it is an adjective"—and in the laughter that followed

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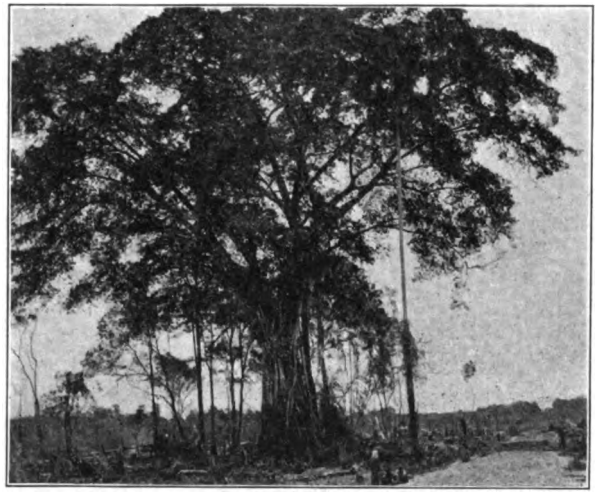
he escaped. I have always believed that in these brief sentences he told all he knew about a very remarkable substance.

That a certain amount of information about the gum, however, is of value to all of those who use tires is incontrovertible.

Almost anyone knows that india-rubber comes from the sap of a tree; that is, anyone but a few experts, and they know that it does *not* come from a *sap* at all. Instead of that, it is a white, usually thick, milky juice, contained in the spongy bark of various tropical trees, and is totally distinct from the sap. These trees are found in the tropics the world over, and embrace many hundreds of species, only a few, however, producing rubber of commercial value.



RUBBER TREE OF ASSAM, INDIA (FICUS ELASTICA).

The standard value in the crude rubber market is the Pará rubber, produced by a tree that is found wild in great abundance in the valley of the Amazon. Rubber is gathered by the native workers who cut into the spongy bark of the tree, collect the rubber milk in cups, coagulate it in a variety of ways and ship it to factors in different centers, who in turn get it to such great markets as New York, Liverpool, Antwerp, and Hamburg.

India-rubber comes in a great variety of shapes, the best of which is fine Pará, in the form of biscuits. The coarse Pará, which is the scrap, comes in chips and strings, and uneven bits bound together in balls, known as "negroheads." From Central America come great slabs of rubber almost black, and often full of clay and stones. From Africa, little balls and spindles, frequently full of reddish bark and chips, and so on—differ-

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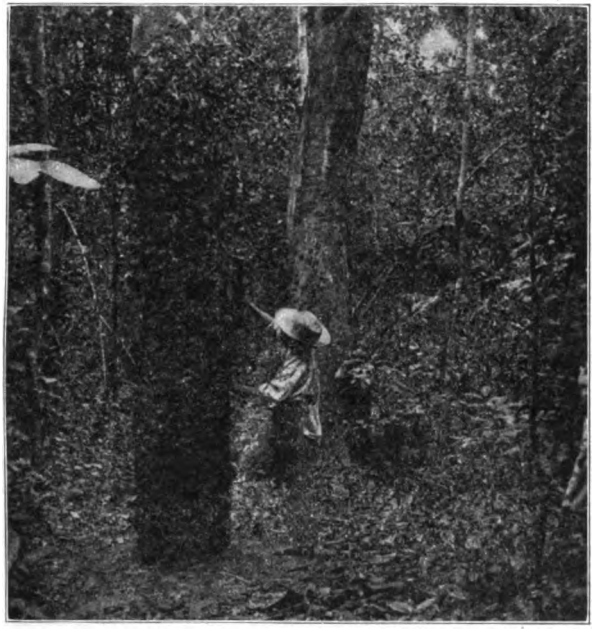
ent localities shipping rubber in different shapes and conditions, and under many names. The rubber itself varies widely in value and in chemical constituents, so that it will be seen that the manufacturer in purchasing has before him a problem of no mean proportions, to bring out of such crude materials goods that are up to the standard in resilience and durability.

Just here it may be well to explode another popular fallacy. For some reason the belief seems to be prevalent that the natives the world over destroy the trees in securing the rubber. This is true only to a degree.



TAPPING A RUBBER TREE (HEVEA BRASILIENSIS) IN SOUTH AMERICA.

The rubber that is gathered from the vast basin of the Amazon comes from a tree that produces more rubber by constant tapping through the dry season than could possibly be secured by cutting the tree down; hence the trees are carefully preserved. Through Central America, where another type of tree is found, most of the trees have been destroyed. Their places, however, bid fair to be taken within a few years by the great plantations that have been installed, and which in the next five years will undoubtedly produce large quantities of rubber. Furthermore, in the African fields, where millions of rubber trees and vines have been

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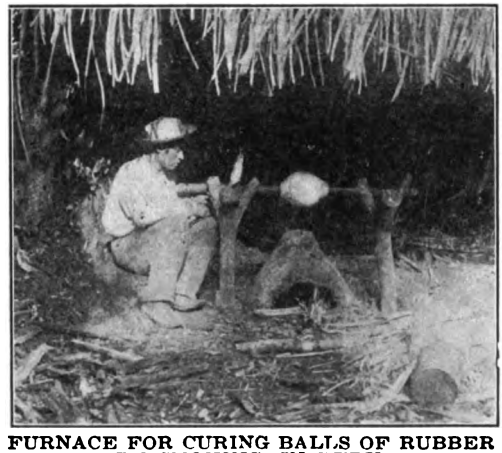
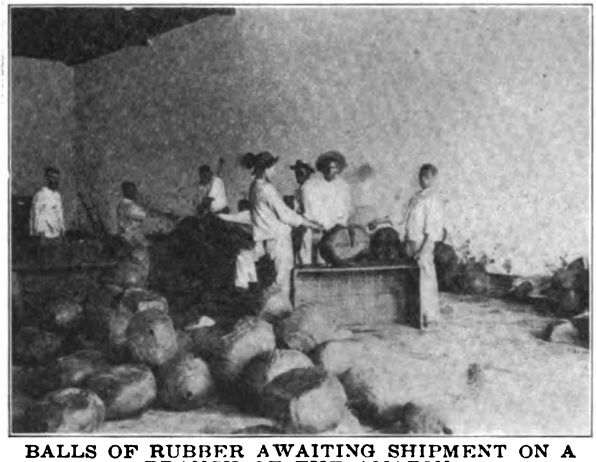
sacrificed, there have in the last two or three years been many millions more planted to make good that loss.

The great field of the future, however, bids fair to come from the



FURNACE FOR CURING BALLS OF RUBBER BY SMOKING, IN PERU.

enormous plantations of Pará rubber trees that have been installed in Ceylon and the Federated Malay States, owned by English capitalists and operated by native labor under European overseers. These plantations



BALLS OF RUBBER AWAITING SHIPMENT ON A BRANCH OF THE AMAZON.

are at the present moment just coming into bearing, and so successful have they been and the profits so satisfactory, that in a very few years the 20,000,000 trees now found in those great orchards will doubtless have

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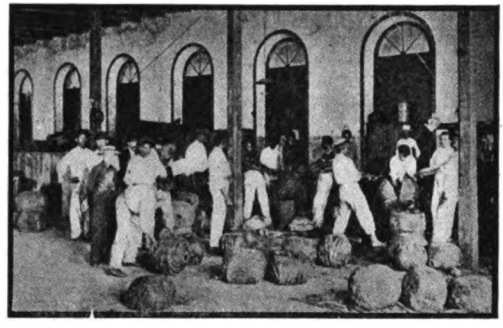
increased to a hundred million. It will thus be seen that the destruction of the trees by the natives is counteracted by the new plantings. The wonderful expansion of the rubber manufacturing business, however, is at the present time making a demand that is constantly encroaching upon the supply, and while there is no danger of a rubber famine, it is certain that the price of crude rubber will rule high for some years to come.

The fact that rubber is high, and that it has so constantly increased in price, is due solely to the ancient law of supply and demand. Manufacturers want it for tires, for boots and shoes, for insulated wires, for



GRADING RUBBER AT WAREHOUSE IN MANAOS.

surgical goods, for clothing, for belting and hose, and for minor uses innumerable. There are at times little flurries of speculation that force the price up a bit, but they have no permanent effect upon the market.

May I explode another popular mistake; rubber is *not* gutta-percha, never has been and never will be. Gutta-percha is a horny substance that comes from the milky juice of a tree, to be sure, but while it is plastic under the heat, it has no stretch, no resilience, and cannot be vulcanized. A pneumatic tire made of gutta-percha would be no more conducive to comfort than one made out of hard wood.

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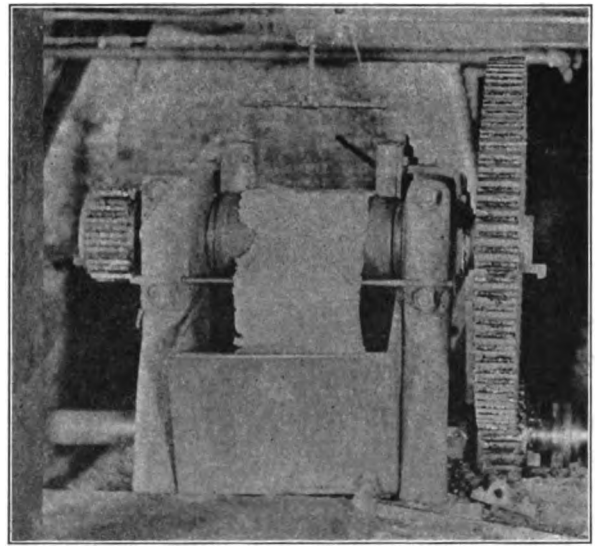
CHAPTER II.

HOW RUBBER GOODS ARE MADE.

JUST as the baker takes flour and water and salt and yeast, makes a dough and bakes it, so does the rubber manufacturer take rubber and sulphur and various powders, make a dough, and bake it. That is, roughly, the whole process. There is no melting or casting, as



WASHING CRUDE RUBBER.
[Showing rollers through which rubber is passed again and again until washed and formed into sheets.]

so many believe. It is simply a baking business with a sticky gum as a foundation that during the baking changes into an unsticky gum, which is also more elastic than it was before, and, indeed, has added to itself a score of valuable qualities.

Rubber, sulphur, baking—that is the whole story.

As the baker, by putting different materials into his dough, produces not only bread, but biscuits, cakes, pies and the like, so the rubber manufacturer adds to his dough to make tires, rubber belts, packing, or hot water bottles.

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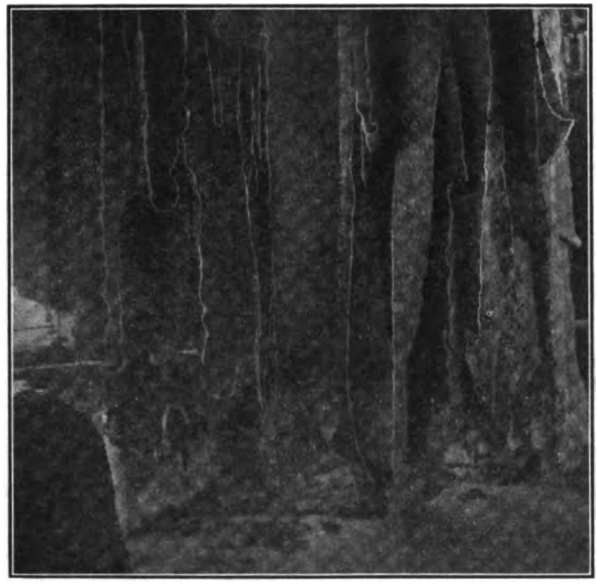
For example, if cheapness is desired, whiting is put in; if toughness, oxide of zinc; if slipperiness, plumbago; if heat resisting quality, powdered asbestos, and so on, *ad infinitum.*

Soft rubber contains but little sulphur and is baked but a short time. Hard rubber, or vulcanite, contains much sulphur and is baked many hours.

When the crude rubber reaches the manufacturer, it is full of impurities which must be washed out. So it is run through the washer, a sturdy machine consisting of two corrugated rolls turning towards each



DRYING CRUDE RUBBER.
[Washed sheets hanging from rods near the ceiling and exposed to a current of warm air until thoroughly dry.]

other; and as they chew the lump into a ragged sheet a stream of water washes away the dirt. When clean the thin sheets are hung up in a slightly heated room until bone dry. Then, and not until then, is it ready for mixing.

In this sheet form it is tough and harsh to the touch and does not suggest a dough at all. But when run again and again around one smooth roll of the mixing mill, it becomes soft, slightly sticky, and readily takes up almost any ingredient that in powder form is to be mixed with it.

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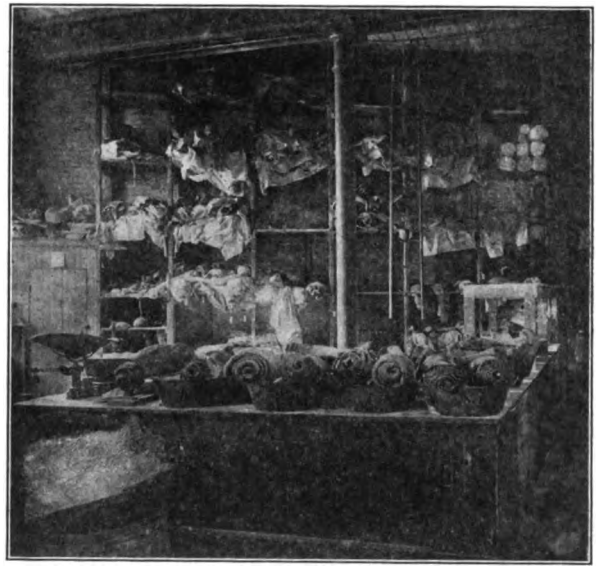
When the mixture is complete, the mass is in the form of a log, smooth, dark colored, and very dense. To be able to use it the mass must be ironed out into sheets. This is done by huge calenders, which are heavy steam heated rolls that squeeze it into long sheets on cloth aprons, when it is ready for cutting up into shapes that are parts of the finished article. These parts are pasted together with rubber cement; the article is placed in a mold to give it shape, and in that mold it is kept until thoroughly baked.



COMPOUND ROOM.
[The pans in the foreground contain "batches"—that is, so much rubber, together with sulphur and ingredients for compounds—ready to go to the mixing machine.]

The layman believes that anyone who is making rubber goods knows all about all lines of rubber manufacture. The exact reverse of this is true, as the business has divided itself into a half score of absolutely distinct industries.

One of the most important of these today is that of the rubber tire. Even this division of the industry divides itself again into two parts quite distinct from one another—solid tires for cabs, carriages, etc., and pneumatic tires for cycles and motor cars. Separate factories are operated for both of these and an expert in one may know little or nothing about the other. The tire, it is well to remember, belongs to the great general

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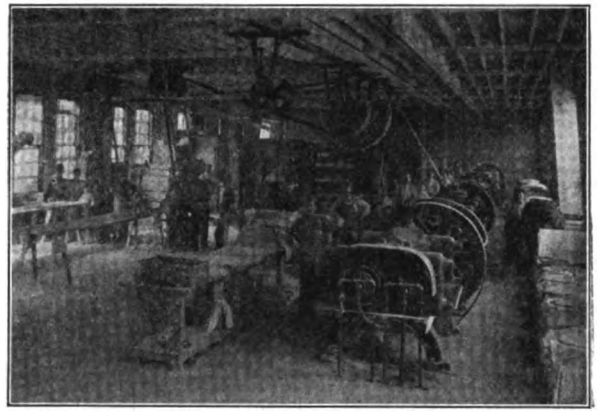
division known as mechanical rubber goods, which embraces belting, packing, hose, valves, matting, and a thousand minor articles used in connection with engineering and manufacturing.

Rubber shoe making is another separate industry. Compounds, machinery, and baking ovens all are different from other lines, and the most skillful rubber shoe manufacturer may know nothing about the manufacture of tires.

Insulated wire, the rubber type, calls for yet different treatment in compounding, in machinery, and in baking.

Great factories devoted only to the manufacture of hard rubber goods turn out telephone receivers, fountain pens, combs, and like goods, and



MIXING AND CALENDERING ROOM.
[In the background is the big three roll calender for sheeting, while in the foreground are several mixing rolls.]

the makers know no more about other lines than they do about making radium.

The factories that produce water bottles, atomizers, and physicians' supplies, pass as druggists' sundries manufactories and stick as a rule to that line only.

Rubber clothing, automobile tops, carriage drills, and similar goods, form still another division of the great industry.

Specially prepared rubber for the use of the dentist and the rubber stamp manufacturer have their own formulas, skilled employees, and separate factories.

The dress shield is a tiny thing as compared with a huge grain elevator belt, but factories are equipped for its manufacture alone and the yearly product is very large.

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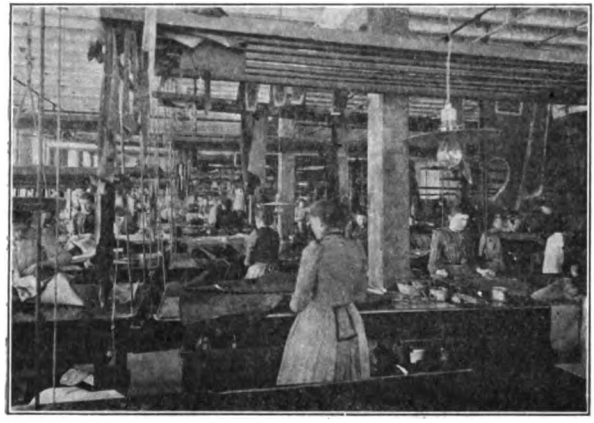

MAKING UP ROOM.
[Various parts of the rubber goods are here stuck together with rubber in solution and made ready for baking.]

Putting rubber into solution, preferably with naphtha, is an industry by itself, the product being sold in thousand barrel lots.

Thus this great business, so remarkably divided, touches almost every industry and profession, nay, touches in some way every individual. That is perhaps what makes it one of the least known, most misunderstood, and at the same time the most fascinating of all of the manufacturing trades.

VULCANIZING ROOM.
[The ovens at the left are those in which the goods are placed to undergo the process of baking.]

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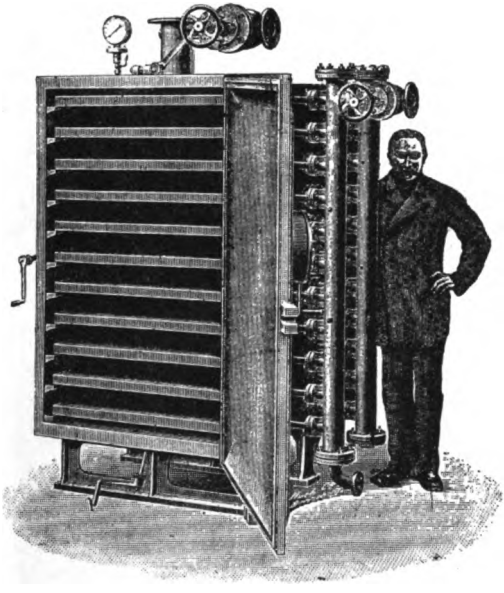
CHAPTER III.

AUTOMOBILE TIRE MANUFACTURE.

THE automobile tire is, of course, only a very large cycle tire; that is, generally speaking. It, however, involves problems in the way of making up, vulcanizing, and, indeed, structural form that make it a much more complicated problem than the other. The basis of it is rubber, which, once it is in the factory, is run through heavy corrugated rolls, between which passes a stream of water, and this is the wash-



VACUUM DRYER FOR RAW RUBBER.

ing process. Then it is hung to dry, sometimes for months. It is next put on smooth rolls, steam heated, which, running together, "mass" it, making it smooth and homogeneous, and then is added the sulphur for vulcanizing and other ingredients for rendering it tough and wear-resisting. From these rolls in the form of plastic dough, it is taken to the calenders, where it is run into sheets preparatory to the building up of the tire.

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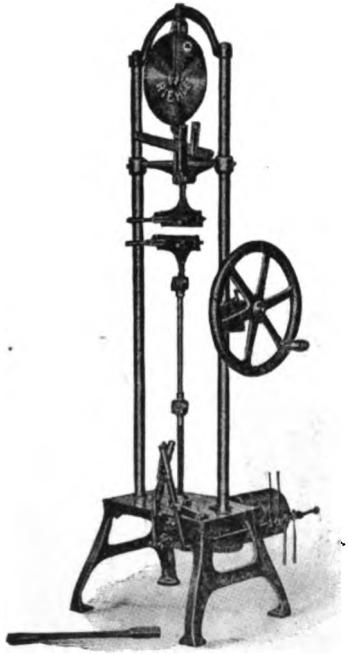
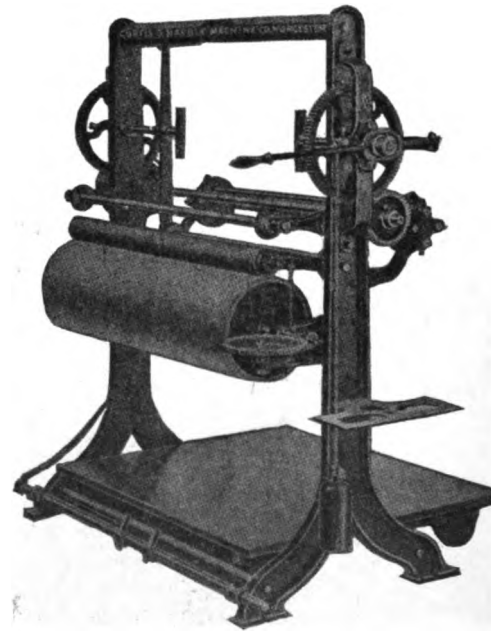
There is oftentimes an expressed wish on the part of tire purchasers that they be assured that they are getting only "pure gum"; that is, rubber with the simple addition of from 6 per cent. to 10 per cent. of sulphur. This assurance is often given, but as a matter of fact they neither need nor do they receive pure gum. India-rubber has the curious quality of assimilating almost all kinds of earths, metallic oxides, and even vegetable substances. From these it borrows various qualities that are oftentimes of great advantage. For instance certain ingredients used in hose help the rubber to resist oils, others assist in delaying the de-



MACHINE FOR TESTING STRENGTH OF TIRE FABRICS.



WINDING AND MEASURING MACHINE—TIRE FABRICS.

structive action of acids, hot water, etc. Some earths give a soft putty like consistency, while others make a compound hard and only slightly elastic. All of these peculiar attributes that rubber may take on are known to the manufacturers, and it is safe to say that today only a few adulterate tires for the mere sake of cheapening them. They do not use pure gum, in the strict sense of the term, for the reason that it would not last as well as rubber combined with a percentage of metallic oxides that will give it better wearing qualities, and while not affecting its resilience, will keep it from tearing. It is safe to say that there is not one successful

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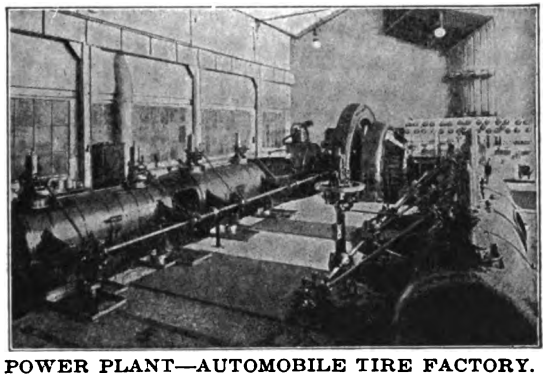
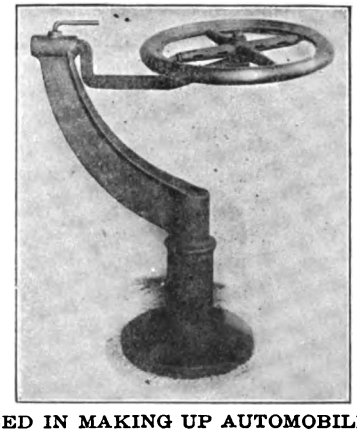
manufacturer of tires today in the world, who has not in spite of all his experience in the compounding and manipulation of rubber, been forced to try hundreds of experiments, and learn by actual experience exactly what rules should be followed to enable him to turn out tires that should give first-class service.



POWER PLANT—AUTOMOBILE TIRE FACTORY.

After the rubber is mixed the next step is to put it in shape so that it can be made up, and the first thing is to get it upon the fabric that forms so important a part of the tire. For this purpose it is taken to the calender, a massive machine in which are steam heated rolls, that not only smooth



JACK USED IN MAKING UP AUTOMOBILE TIRES.

the rubber out in a thin and even coating upon the cloth, but also drive it between the meshes so that every space is filled with gum. It should be borne in mind that the strength of the tire depends largely upon the fabric. Its elasticity and its airproof and waterproof qualities, come from the rubber.

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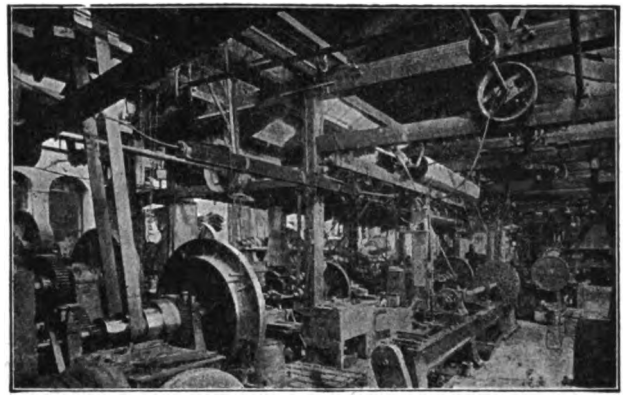
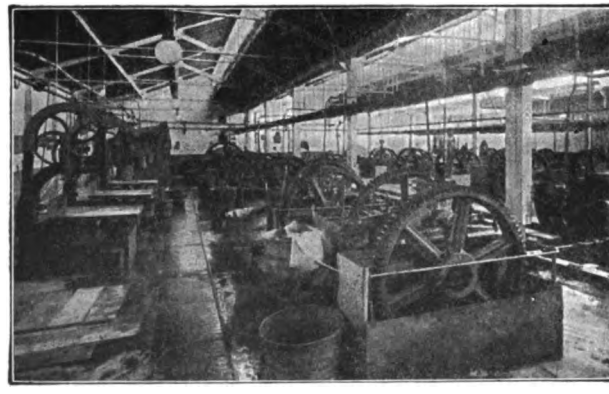
The rubber coated fabric as it comes from the calender is next taken to the cutting room where it is cut into strips, and from there it goes to the making up departments, where it is shaped roughly, like the finished tire. When any parts are to be joined, rubber in a benzine solution is



MACHINE SHOP IN TIRE FACTORY.

used as a cement. Forms are used for the making up, that allow the workman to give it its general shape. Its final finish is given by pressure during the vulcanizing.



MIXING ROOM—AUTOMOBILE TIRE FACTORY.

Next comes the baking process. To keep the tire in place while it is being baked, it is placed in a huge steel mold, made in two parts, which are bolted together or else held in place by hydraulic pressure. This mold is then placed in a vulcanizer, that is, a great steam chamber, into which

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live steam is sent and a certain heat obtained, enough to accomplish the baking. That being completed, the vulcanizing chamber is opened, the mold taken out, in its turn opened, the tire removed, and passed on to the inspectors.

These processes, while apparently simple, require very much skill, and no manufacturers of automobile tires today are doing anything but using the finest materials and doing their utmost to produce the very best possible results. Indeed, the fact that tires are as good as they are, is a marvelous testimonial to their ability and conscientiousness. No other problem in the whole varied line of rubber manufacture offers so many difficulties and in none has there been such wonderful advancement. Whether the tire of the future will be pneumatic or not it is impossible as yet to say. At all events, until something has been evolved to take the place of the air cushion as a check to vibration it will continue in general use on pleasure vehicles.

Just at this point it might be well to correct the very general belief that the manufacture of tires is a veritable gold mine. The only way to prove this is to cite a few items of cost that go not only to make the tire high priced, but cut profits down appreciably.

Pará rubber, $1.20 to $1.30 a pound.

Shrinkage of rubber after washing and drying, 20 per cent.

Cost of grinding, mixing and calendering.

Preparing and weaving special cotton fabric.

Labor in building up tire.

Vulcanizing, testing, and inspection.

Loss on "seconds."

Shop expenses; that is, interest, depreciation of plant, taxes, insurance, water-rates, gas, coal, oil, etc.

Salaries of superintendent, clerks, engineers, watchmen, and non producers.

Experimenting; a large item in these days where improvement is always sought.

Selling expenses; that is, salesmen, traveling expenses, advertising, office rent, clerkage, insurance on stock, freight, teaming, etc.

Interest on stock carried to fill orders promptly, and depreciation of stock.

Replacing tires actually defective or alleged to be so.

Bad accounts.

To sum up the above: Under the most favorable conditions, a large manufacturer can make today not over 15 per cent. profit on pneumatic tires. Now, on a staple which does not change from season to season, like garden hose or cotton goods, a profit of 10 or 12 per cent., or even less, is by no means to be despised—on a large production; but for patented articles, so treacherously provocative of misrepresentation as pneumatic tires, a profit of 15 per cent. is quite too small.

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CHAPTER IV.

THEORY OF THE PNEUMATIC TIRE.

THE demand for greater speed and comfort in vehicular travel in an age marked for its ease loving and labor saving propensities was what brought out the pneumatic tire. All sorts and kinds of carriage springs were adopted and rejected, but the endless iron hoop that bound the wheel has only recently given way to the rubber tire, solid, cushion, and pneumatic.

Of course, the first question to be considered in the demand for comfort is the minimum of vibration. This is accorded to the pneumatic on account of its greater resilience, for a pneumatic tire is practically a vibration annihilator.

In order to get the greatest degree of comfort the line of least resistance must be followed, at any rate so far as tires are concerned, and the elasticity of air and its shock resisting qualities are unchallenged today. The great disadvantage to be considered is that rubber is the only elastic, air confining medium at the present time, and it is liable to puncture. As internal pressure is the force used to meet and overcome the external obstacles, it will readily be seen how the principle involved is one that has not, up to the present time, been improved upon.

For example, when a pebble or small stone lies in the path of a vehicle whose wheel tires are of metal, the entire weight of the wheel has to be lifted over the stone, at a great expenditure of motive power, as well as at the price of discomfort. When the same obstacle is encountered by solid or cushion tires, the elasticity of the rubber determines the conditions governing loss of force, discomfort, etc., but when the pneumatic passes over the obstruction the loss of energy and unpleasant vibration have been reduced to a minimum. It has simply meant the displacement of the compressed air, for the instant, the combined elasticity of the air and the thin covering of rubber making this possible. The greater the speed, too, the greater the ease with which the obstruction is overcome.

It requires only a moment's thought to understand why so much is overcome with an expenditure of energy so trifling. Of course it is a well known fact that the internal pressure of the pneumatic tire increases in proportion with the load which is to be carried. The total pressure

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distributed throughout the air chamber of the tire will be equal, on the entire bearing surface in contact with the road, to the total weight of the load divided by the number of wheels. For instance, a 2,000 pound four wheeled car would, if it were possible to distribute the weight equally, make a 500 pound burden on each wheel, and when pumped up sufficiently to support this load with ease, the air cushion would hold the wheel in equilibrium. However, the internal pressure is increased by the flattening of the tread where it comes in contact with the road, but this factor being constant on a smooth road, the only work to be performed by the tire continually is that entailed by the bending of the rubber in the side walls. This is lost energy, but inasmuch as the pressure is constant and the air round the wheel is continuous, the degree of energy thus lost is brought to the lowest possible point. Although air is being constantly displaced, the rapidity with which expansion succeeds compression as the tire makes its revolutions, overcomes the effect of the work almost wholly. In the solid tire work is done by the rubber, its inherent compressibility being constantly tested by repeated compression and expansion and attendant heating. Generation of heat is, of course, another source of lost energy. It is true that on a rough road the obstacles make increased compression in the air filled tire, but the rapid expansion robs it of its heat, and expansion and compression are again counter irritants.

In the matter of speed the law of least resistance again obtains, and the pneumatic is still in the lead. This must of necessity remain so, for the reason that there can be no perfectly smooth road. Given a roadbed of absolute smoothness and the pneumatic tire would require a propelling force far in excess of that of metallic tires, because of reduced friction, the motive power being exhausted not by overcoming friction but by the force required in lifting the wheel over obstacles. From this it will be seen that a horse, in drawing a carriage equipped with pneumatic tires, could do the work of two drawing a carriage equipped with metal tires.

Another reason why pneumatics are faster is that they lower the grade of the roadbed. Any road surface has a layer of dust which, though it may seem a trifling consideration, plays its part in the final computation. The constant compression of this layer of dust by the solid tire changes the grade, making a slight but continual rise, this fact, of course, holding good appreciably when a moderate amount of speed is considered. The pneumatic covers so much more road surface at the point of contact by reason of ease by which it is compressed that it tends to lower the grade. This may be better understood when it is taken into consideration that steel rails require 25 per cent. less force to carry a ton

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weight, because of their being harder, than iron rails. The rail depression is not noticeable, yet it exists. The same principle holds good in tires either over a smooth or hard surface, and this is especially true of the ordinary pavements, when the tires must sink somewhat into the crevices between the stones.

Theoretically, then, from every standpoint, it would seem that the pneumatic tire is very near perfection. To be sure, the spring wheel is being considered widely as a substitute, but if some genius could arise from the ranks of tiredom to provide a delicate, air confining fabric that would be virtually puncture proof, the problem would be solved and pneumatic tires would demonstrate all, and more, than theorizing has ever claimed for their supremacy.

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CHAPTER V.

WHEEL AND TIRE SIZES.

IT goes without saying that on a vehicle of any given type, wheels of a certain size would be preferable to any other, but in most cases the ideal size has not been determined. There is no accepted scientific law for determining the proper wheel diameter for different kinds and weights of vehicles, such details being left to chance and ultimately being governed by custom. Wheel sizes have been a matter of experiment by carriage makers for centuries, and the prevailing sizes in use on horse drawn vehicles may perhaps be accepted as embodying the essence of superiority in this line. But it does not follow necessarily that such sizes are equally adapted for automobiles, for example.

In the early days of cycling wheels were used up to 60 inches in diameter, and it was believed that speed could be made only with large wheels. When the 28 inch wheel "safeties" came in, they were regarded as very suitable for old men or for timid people, but not at all for racing. Later, however, it was discovered that the small wheeled safeties could be propelled at a higher velocity than the older style. It must be mentioned, however, that there came in with the safety bicycle a new method of applying power to the wheel, and the pneumatic tire. But the fact that the large bicycle wheel has gone out of use is proof of the superiority of the smaller diameters. In like manner it is to be expected that in time the wheel sizes best adapted to automobiling will be determined upon and accepted in general practice. And in this connection must be considered the fact that the auto wheel is invariably equipped with pneumatic tires.

When the automobile makers began to put their goods on the market they seemed to feel, and in this the public agreed with them, that there was some connection between the auto and the bicycle, and that bicycle experience was of value in the auto business, and they therefore adopted the 28 inch wheel and the heaviest bicycle tires then available, usually a strongly constructed 2 to 2½ inch tire, such as had been used on triplets or quads. The reason for this adoption may have been and probably was the fact that these tires, being standard, could be purchased more cheaply than special sizes, and therefore permitted the auto maker to turn out his goods more cheaply. Other sizes, however, could have been had at slightly increased price and might have given greater satisfaction. Doubt-

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less the question of price has tended to limit experimenting with larger wheel diameters, though with the introduction of autos of increased weight tires of larger cross section have come into use.

It has been argued that as the use of pneumatic tires smooths the road, a large wheel is not so necessary on an automobile as on an iron tired horse vehicle; but this is not good reasoning, for the use of the pneumatic permits higher speed, and there would appear to be reason for wheel sizes to remain the same. It is true that large wheels are not so strong, relatively, as small ones, but loads much heavier than automobiles are carried on large wheels, so this need not be considered a serious difficulty.

In choosing wheel sizes for automobiles ease of riding and light road resistance are to be taken into account. It does not seem unreasonable that horse vehicle sizes should be used on an auto where speeds are higher and the effects of the rough roads more pronounced than in the horse vehicle. Railroad car wheels are quite commonly 36 inches in diameter, although they run on the smoothest roads in existence, and locomotive wheels, as also traction engine wheels, are decidedly larger. It would, therefore, seem that the 36 inch wheel is as small as should be used under vehicles having an average weight of about 2,000 pounds. Perhaps on most roads 40 inch wheels, or even larger, would be better.

A large wheel rolls over the obstacle, and lifts the load over easily, whereas the small wheel rolls against the obstacle, jolts badly, and rises over it with difficulty. This is not only unpleasant for the passengers, hard on the mechanism, and wasteful of power, but it throws a much greater strain on the rubber tire, thus materially lessening its life, and this is a most important consideration, in view of the heavy cost of tires.

The argument in favor of large wheel diameters, instead of increasing the width of tires, is thus expressed by Charles E. Duryea:

"Increased tire sections lessen this effect by cushioning it, but the increased wheel diameter obviates it. The air pressure strain on the fabric of a properly designed tire is largely a matter of cross section, and a small tire on a large wheel is less likely to burst than a large tire on a small wheel. Further, the small tire does not make so wide a track, and is therefore not so exposed to likelihood of puncture as is the large tire. The large tire rolls over the sand more easily, but in going through mud or snow it meets a far greater resistance, and is therefore less economical than the small tire, particularly when wheel diameters are considered. The large wheel turns less times per mile, so its tire bends less frequently and wears longer. The large wheel with small tire throws less mud,

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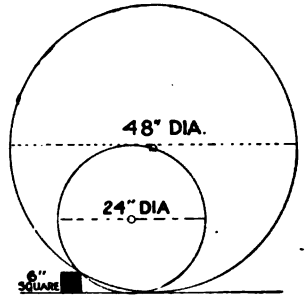
raises less dust, skids less, is less affected in case of a burst tire, and is generally better than the small wheel with large tire."

Primarily, the sizes of tires and the weight they have to carry have a close and intimate relation. There are other considerations, of course—the weight and thickness of the enveloping walls, the weight and weave of the fabric, the shape of the tire and the rim, the character of the road, and so on. But each of these is of less real importance than the weight of the load to be carried. There is an analogy between the behavior of a tire and that of any other component part of an automobile. An engine or battery that is too small for a car is being constantly overworked, and its relegation to the scrap heap comes proportionately sooner as the burden imposed upon it increases. It is quite as possible to overwork rubber, and the result is the same. The buyer of a tire not suited to its work fails to



WHEEL SIZES.

[Two feet and four feet diameter; the small wheel must rise over the obstacle in a forward travel of about two and one-half times the height of the obstacle; the large wheel rises four times the height; the jolt and strain are correspondingly less.]

get an adequate return for his investment, and its use is a constant invitation to disaster.

Albert L. Clough makes this comparison of the stress under which rubber tires work on two types of motor car—a gasoline carriage weighing 1,800 pounds, equipped with a motor delivering 8½ horse-power to the wheels, and a motorette of 750 pounds and furnishing 3½ horse-power on the rims. These two vehicles are almost equally powered; that is, the ratio between weight and effective horse-power is the same in both. Hence the tractive stresses on the tires are naturally in proportion to their respective weights. At a low gear speed of 8 miles per hour, the maximum tractive effort per wheel of the heavy car figures about 200 pounds, and in the moderate about 82 pounds. Assuming two-thirds of the weight of

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each vehicle to rest upon the driving wheels, each rear tire of the heavy carriage has to sustain a weight of 600 pounds in addition to the 200 pounds tractive effort, while in the motorette the weight per driving wheel is about 20 pounds. To secure the same factor of safety in operation, the tires of the heavy vehicle must be secured to the rims with lugs 2.4 times the strength of those employed on the motorette, and the resistance of the materials of the tires—resisting, tearing or separation of the several layers —must be in the same ratio. In order that the tires of the two vehicles shall show the same proportion of flattening under their respective loads, with the same air pressure, their cubic contents must be in the relation of 2.4 to 1; otherwise the air pressure must be increased and suitable allowance made for it. To apply this ratio, it may be noted that, supposing a tire of 2½ inches to be sufficient for the lighter vehicle, one of about 3⅞ inches would be required for the heavier one, with a proportionate increase in the strength of materials.

Weight, of course, is not the sole factor to be considered in determining the sizes of tires. The volume of compressed air within the tire, the nature and construction of the tire cover, the speed of the car, the heat generated within the tire, and the attachment of the tire to the rim also have to do with the case.

Compressed air in motion generates heat. The faster the speed the greater the heat; the greater the heat, the greater the strain on the tire; the larger the tire, the less the increase of heat and strain. So it will be understood that the faster the speed the greater the load per wheel and tire. If there is not sufficient volume of compressed fluid air within a tire to absorb the whole of the shock or vibration, the surplus shock is received by the cover of the tire, which dashes it to the car and engine, causing damage to the tire and to car in a similar manner to the way in which a pool of water receives a solid body thrown into it. If the pool be small, the reception of the shock causes a violent dashing of water against the banks; if the pool be large enough the disturbance is imperceptible. As the compressed fluid air within a tire must be reached through the solid cover, it stands to reason that the cover should be as yielding, flexible, and sensitive as is consistent with road wear and tear, to interfere as little as possible with quick communication of shock to the fluid cushion.

In the tables of load weights and tire dimensions which follow use has been made of the figures given by some of the leading manufacturers of pneumatics:

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TABLE OF CAR WEIGHTS AND TIRE SIZES OF "LE PERSAN" TIRES (THE INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS CO.)

MILLIMETERS.	KILOGRAMS.	INCHES.	POUNDS.
(*a*) 65	550	2½	1,210
(*b*) 90	900	3½	1,980
(*b*) 100	1,000	4	2,200
(*c*) 105	1,050	4⅛	2,310
(*d*) 120	1,200	4¾	2,640
(*d*) 125	1,300	5	2,860
(*d*) 135	1,400	5½	3,080

Capable of Sustaining a Speed of—

(*a*) 45 kilometers (= 28 miles) per hour.
(*b*) 60 kilometers (= 37 miles) per hour.
(*c*) 70 kilometers (= 43½ miles) per hour.
(*d*) 90 kilometers (= 56 miles) per hour.

TABLE OF CONTINENTAL CAOUTCHOUC UND GUTTAPERCHA COMPAGNIE.

LIGHT TIRES.	POUNDS PER WHEEL.
(*a*) 28 to 32x3¼ inches	300
(*a*) 28 to 32x3¼ inches	480
28 to 32x3½ inches	660
28 to 32x3½ inches	700

(*a*) For front wheels only.

HEAVY TIRES.	POUNDS PER WHEEL.
26 to 56x2½ inches	600
28 to 46x3½ inches	950
30 to 36x4 inches	1,000
32 to 36x4¼ inches	1,140
32 to 44x5 inches	1,300
32 to 36x5¼ inches	1,400
35 to 37x5½ inches	1,760

TABLE OF TIRE SIZES, G & J ASSOCIATION (UNITED STATES), FOR GUARANTEES, YEAR ENDING SEPTEMBER 1, 1906.

	POUNDS PER WHEEL.
28 to 36x2½ inches	225
28 to 36x3 inches	350
28x3½ inches	400
30x3½ inches	450
32x3½ inches	550
34 to 36x3½ inches	600
30x4 inches	550
32x4 inches	650
34x4 inches	700
36x4 inches	750
32x4½ inches	700
34x4½ inches	900
36x4½ inches	1,000

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TABLE OF TIRE SIZES AND WEIGHTS OF MICHELIN ET CIE.—EXTRA STRONG VOITURETTE OR CAR TIRES.

Type of Tire in mm.	Maximum Weight the Tire can bear	When the Tire carries	Pressure per square inch required	Maximum Deflection* Flat Treads	Round Treads
65	600 lbs.	330 to 440 lbs. 440 to 600 lbs.	50 lbs. 64 lbs.	1¾ in.	2 in.
75	480 lbs.	330 to 440 lbs. 440 to 480 lbs.	50 lbs. 57 lbs.	1¾ in.	2 in.
85	660 lbs.	440 to 550 lbs. 550 to 660 lbs.	64 lbs. 71 lbs.	1¾ in.	2⅜ in.
90	990 lbs.	550 to 770 lbs. 770 to 990 lbs.	57 to 71 lbs. 71 to 78 lbs.	2½ in.	2 in.
105	1140 lbs.	660 to 990 lbs. 990 to 1140 lbs.	57 to 71 lbs. 71 to 78 lbs.	2⅝ in.	2⅝ in.
120	1320 lbs.	880 to 1100 lbs. 1100 to 1320 lbs.	64 to 71 lbs. 71 to 78 lbs.	3 in.	3 in.
135	1490 lbs.	1100 to 1430 lbs. 1430 to 1650 lbs.	71 to 78 lbs. 78 to 85 lbs.	3 7/16 in.	3 in.
150	1650 lbs.	1100 to 1430 lbs. 1430 to 1650 lbs.	78 lbs. 85 lbs.	4 1/16 in.	3¾ in.

*Minimum distance between edge of rim and the ground.

In the tables which have been given it is assumed that the weight of the car is evenly divided between all four wheels. Of course, this is usually not the case. To determine the way in which the load is distributed, weigh first the front and then the back part of car separately by running first one and then the other half on the platform scales. Add the two weights together, and they should correspond to the total weight of the car. The weight of one-half of the car divided by two is the weight per wheel for front or rear axle, as the case may be.

It will be seen how the weights allowable per wheel for tires of a given size differ in the several tables. It is difficult for the same factory to make two tires of exactly the same capacity. Different makes of tires may vary widely in strength, due to difference in the quality and weight of the fabric used, the treatment of the fabric, the method of building up the tire, the contour of the tire, and so on.

The records of an automobile reliability contest in the United States in the latter part of 1902 give the average weight of the cars participating (including weight of passengers) as follows:

For 14 vehicles.....2½ inch tires, 1,427 pounds.
For 29 vehicles.....3 inch tires, 1,695 pounds.
For 15 vehicles.....3½ inch tires, 2,280 pounds.
For 11 vehicles.....4 inch tires, 3,056 pounds.

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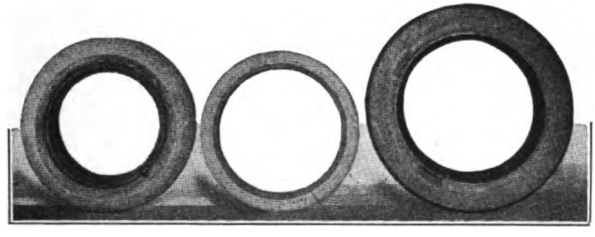
Tires are usually referred to by their width, a driver saying, for example, that he has "4-inch" tires on his car. But they are made in various diameters for any given width, and in ordering new tires for a wheel it is necessary to state both diameter and width. By the way, a tire is measured on the outside of the tread for the diameter.

A tire maker is quoted as saying that with a high carriage wheel, a rubber tire, and a roller or ball bearing axle, there is likely to be trouble, though this is most often due to want of sufficient care of the axle bearings. The high wheel, rubber tired, seems to have too much room for play (in the form of leverage) to run at its best on the ball or roller bearings. Another authority says the tire channel undoubtedly stiffens a light wheel considerably, and so, destroying the elasticity, throws all the compensating motion into the hub. It is communicated in turn to the bearings, and so creates trouble. The merits of the easy running axle give it a sure place, and the merits of the rubber tire give it a sure place. The question is what size of wheel is best fitted in the combination of rubber and ball bearings to obtain the greatest utility of both.

Rubber men are agreed and the carriage builders in many cases concede that provided the size of the tire is proportionately increased, there is no limit in ordinary work to its load utility. The maximum size in pneumatic tire construction probably has not been reached. The largest tires yet reported were made by the Continental company for use on London motor 'buses—1035 x 165 mm. (40 x 6½ inches). The weight of the cover alone in such a tire is 83 pounds, whereas in the normal sized tire of 34 x 3½ inches it is only about 14½ pounds.



RELATIVE SIZES OF PNEUMATIC TIRES.
[The largest tire shown is designed for a London motor 'bus.]

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CHAPTER VI.

HISTORY OF THE PNEUMATIC TIRE.

IN any general history of rubber tires the name of Robert William Thomson deserves prominent mention, as the first patentee of such a tire. His patent, issued in England as No. 10,990 of 1845, related to "the application of elastic bearings round the tires of wheels of carriages, rendering their motion easier and diminishing the noise they make while in motion." He suggested using for this purpose "a hollow belt" composed of india-rubber or gutta-percha, and inflating it with air, "whereby the wheels will at every part of their revolution present a cushion of air to the ground, or rail, or track on which they run." This elastic belt, as Thomson called his air tube, he made of several thicknesses of canvas, each saturated with rubber in a state of solution, and laid one upon another, all being cemented together with more rubber solution, after which the tube was vulcanized. Leather was used for the cover, or outer casing, and the tire was inflated with a "condenser" not unlike a modern cycle tire inflater.

It was the size of Thomson's tires, next to the noiselessness of the wheels, that most attracted attention. They were five inches in diameter for a brougham. The London *Mechanics' Magazine* mentioned a set of these tires having been run for 1,200 miles without "the slightest symptoms of deterioration or decay," and there are other references in the papers of that day to the noiseless tires, but they do not appear to have come into use except as a curiosity. The *Scientific American* in 1847 mentioned the appearance of a rubber tired carriage in New York, but the writer has found no further record of the incident. A French patent was issued to Thomson in 1846, and one in America in 1847. It is the subsequent bearing of the Thomson patents upon the tire patent litigation, rather than the immediate importance of his invention, that is of interest in this work. Tradition has it that Thomson's "aerial" wheels were much laughed at, but in time they were forgotten, and when pneumatic tires again appeared their inventors were surprised to learn that Thomson ever existed. About 1868, however, the leading scientific journals of Europe were describing his solid rubber tires (up to five inches thick) for traction engines for common roads.

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The introduction of the velocipede, or bicycle, led to renewed interest in rubber tires, though these were being attached to small truck wheels, and to invalid chairs and bath chairs. By 1884 each of the leading rubber manufacturers in England had filed patents on solid tires for bicycles and other vehicles, some of these patents dating back as far as 1871. They differed in (1) means of attachment; (2) in the compounds used, as where emery was introduced to give the tread greater wearing capacity; and (3) in form—the tread fitted with a "fin," or made of sectional blocks, to avoid "vibration." Macintosh & Co. in 1884 applied for a patent on a tire having a hollow center, or a porous or spongy center, to give added resilience, this being a definite departure from the solid type for bicycles.

It remained for John Boyd Dunlop, a veterinary surgeon in Belfast, to bring out the type of elastic tire which was to have the first great and far reaching effect upon the evolution of the bicycle—the pneumatic tire. The first "Dunlop" tire, it appears, was a rubber tube, with means for inflation, bound upon each of the wheels of a tricycle owned by a young son of the inventor, and held to the rim by wrappings of tape. The result was so satisfactory that Dr. Dunlop applied for and obtained patents in Great Britain—No. 10,607 of 1888, and No. 4,116 of 1889—which were the foundation of the most important single tire company that the world has known.

After having undergone various changes the concern became, in 1895, the Dunlop Pneumatic Tyre Co., Limited, with a capital of £5,000,000 ($25,000,000), and for awhile largely monopolized the pneumatic tire field in Great Britain, besides making large sales elsewhere. In a single year their trading profit exceeded $2,000,000, and dividends were paid amounting to $1,150,000. These figures, by the way, relate solely to the bicycle tire business. But it should be stated that this enormous business was not based upon Dunlop's patents alone. Finally this and the other patents held by the company expired, and the company today, no longer with a monopoly, though still an immense concern, is operating with a reduced capitalization and with smaller profits. The latter has been due to the reduction in price, stated recently to have been £1 17s. 9d. ($9.18) from the maximum per pair for cycle tires.

John B. Dunlop's patents really figured very little in the success of the great Dunlop company. It was early realized that his invention covered nothing that was not anticipated in Thomson's patent of 1845, and the company began to acquire other patents, which will be mentioned further on. The Thomson patent, by the way, was held on the Continent to have anticipated many other later inventions or alleged inventions, so that the

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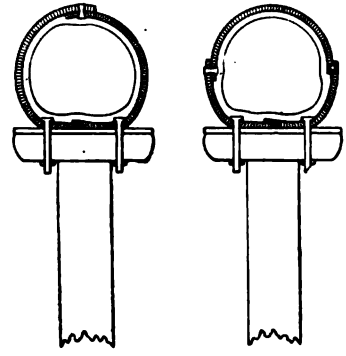
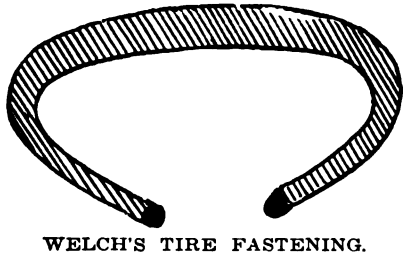
Dunlop tires never had any patent protection in Europe outside of Great Britain.

The merit of the pneumatic tire being soon recognized, the problem remained of devising means of attaching the tire to the rim that could be relied upon to render cycling safe. The Dunlop company early adopted the invention of Charles Kingston Welch, under the English patent No.

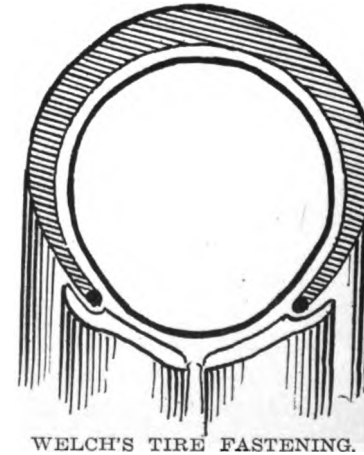


THOMSON'S AERIAL WHEEL.
[The earliest patented pneumatic tire.]

14,563 of 1890, which provided, in addition to an air tube of rubber, a cover of rubber and canvas having thickened edges, through each of which ran a retaining wire, forming a complete circle, the wires lying in a metallic rim specially channeled for the purpose. A singular fact is that, about the same time, an American patent was granted to A. T. Brown and



WELCH'S TIRE FASTENING.



WELCH'S TIRE FASTENING.
[Applicable to a tire inflatable under the Thomson patent.]

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G. F. Stillman, of Buffalo, New York, for a precisely similar invention. (Patent No. 488,494, December 20, 1892.) The fact that their invention was independent and wholly original with the Americans was acknowledged by the Dunlop company in their payment of $100,000 for the patent, and this was the basis of the introduction of the Dunlop tire business into the United States.

The growth of the tire trade naturally led rubber manufacturers generally to desire to profit from it, and not always with regard to patents, and the Dunlop company were soon deep in litigation in the attempt to protect their monopoly. Every feature of construction of their tires was the subject of actions at law in the various courts, leading finally to a decision in favor of the Dunlops in the House of Lords, the highest English court of appeal. Even after this, however, the patents continued to be infringed, and litigation kept on, the company in one year being a party to 162 pending suits. In many cases the company were unsuccessful, with the result that their monopoly was gradually narrowed. On the evening of September 16, 1904, the date of the expiration in England of the Dunlop-Welch patent, at a dinner given by the company, a copy of the patent was consigned to the flames, and the chairman remarked that the expiration could not be viewed with feelings other than those of relief and equanimity. The life of an American patent being seventeen years, the Stillman and Brown patent above referred to does not expire until 1909.

Upon the formation of the Dunlop £5,000,000 company, another important patent was acquired—that of William Erskine Bartlett (No. 16,783 of 1890), covering the "Clincher" principle of tire attachment. Two related Bartlett patents are No. 11,900 of 1889, and No. 16,348 of 1890. Instead of wires for holding the tire cover in place, the cover was made with beaded edges, which engaged the incurved flanges of a clincher rim, so that the inflation of the tire held the cover rigidly. The price paid for this patent was £200,000 ($1,000,000), besides which the vendors, the North British Rubber Co., Limited, retained "shop rights" and continued to make and sell the tires on their own account, in addition to what they made under contract for the Dunlop company. This patent was never successfully attacked in England, and must have proved immensely profitable to the North British company. This company was originally founded by Americans, and Mr. Bartlett, long its managing director, and the patentee of the clincher tire, remained to his death an American citizen. The relative number of "clincher" and "wired on" tires marketed by the Dunlop company cannot be stated, but the former type from the beginning enjoyed a great popularity. The Bartlett patent expired October 21,

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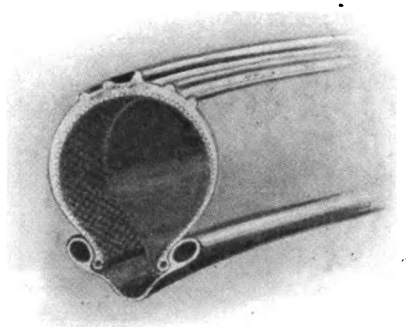
1904. The immediate result was the opening of the British market to tires of the Michelin and "Continental" makes, which, while without patent protection in their own countries, had been sold in Great Britain hitherto only by the payment of royalties to the Dunlop company.

The clincher type of tire was developed in the United States under patents No. 434,115, No. 466,565, and No. 466,789, granted to Thomas B. Jeffery, in 1891 and 1892. The tire was introduced first by the manufacturers of the "Rambler" bicycle, the Gormully & Jeffery Manufacturing Co., at a time when each leading make of bicycles offered a particular form of tire. The fact that this type of tire was identified with a single bicycle factory probably interfered for awhile with its sale, but in time it began to be marketed as the "G & J" tire, and to be pushed in the general



DUNLOP-WELCH PNEUMATIC TIRE.

trade. The American makers carried it to England and began its manufacture there, which was stopped as the result of an action for infringement brought by the owners of the Bartlett patent. Similarly the North British Rubber Co. sought to market their clincher tires in America, when they were successfully proceeded against by the G & J people, although American patents had been granted to Mr. Bartlett.

Meanwhile the "single tube" tire had become the most popular type for bicycles in America, though never coming into wide use elsewhere. But with the introduction of the automobile in the United States, the clincher tire leaped into first place in favor, as was the case in France and wherever else automobiles have appeared. The G & J tire patents are owned by a subsidiary company of the United States Rubber Co.

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which has licensed a number of manufacturers under a royalty and has promptly proceeded to sue for infringement any company, domestic or foreign, marketing clincher tires in America without being licensed. The two principal G & J patents will expire in January, 1909.

While very many different makes of tires, in many countries, are now accessible for automobiles, each manufacturer as a rule offering some special feature, the standard type of pneumatic can safely be said to be the clincher tire. It is this type which was adopted in France by the house of Michelin, whose contribution to the development of the automobile by reason of its work in tire construction is so widely recognized. It is the type, too, which was taken up by the great Continental company, of Germany, and later by other manufacturers in that country. The Dunlop-Welch tire continues to be manufactured, however, with the introduction of new features (in connection with fastenings) from time to time. And a new type of mechanical fastening for pneumatics has been introduced, of which the Fisk tire affords a notable illustration. In this each edge of the cover is held in place by being clamped between a continuous metal plate and the edge of the wheel rim.

In the early days of the bicycle "boom" in America, every manufacturer tried to produce something different from every other, this individuality extending to the tires as well. Among the many tires brought out, the "single tube" tire, patented by Pardon W. Tillinghast, May 23, 1893, and first introduced by Colonel Albert A. Pope on his "Columbia" bicycles, became in time more popular than any other; in fact, it grew to be the standard type for cycles in the United States. The same principle had been worked out in England by A. Boothroyd, who failed to take out a patent, so that the invention became public property in that country, though tires of this type never came into wide use anywhere in Europe. Single tube tires have been used extensively on sulkies and light carriages in America, but on heavier vehicles, including automobiles, certain advantages claimed for the single tube, as in the case of repairing punctures, for instance, have not been experienced. The Tillinghast patent is owned by an association which has licensed the various manufacturers. This association is also subsidiary to the United States Rubber Co. The Tillinghast patent will expire May 23, 1910.

In 1893 there was introduced a special fabric for tires, patented in the United States and Great Britain by John Fullerton Palmer, of the former country. This fabric was what was called in weaving "all warp," having no weft threads crossing the warp. These warp threads were laid on to sheet rubber, and for use as a tire were cut into strips of the desired width, the ends of which were cut on the bias. A strip was helically

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wound on a mandrel, and the opposite edges of the strip were brought into contact in the winding—thus forming a tube. Another strip of this fabric of the same width was superimposed on the first and helically wound in the same manner in the opposite direction. The four ends of the two strips were manipulated in such a manner as to form this tube into an annular tubular tire; an airtight lining previously being provided. A single tube tire was thus formed and was fitted to an ordinary crescent shaped rim, to which it was held by cement as in the old solid tire days. The Palmer tire as first made was essentially a path racing tire, but the principle has been applied gradually to tires for all purposes, including motor tires of the detachable, clincher rim type. The tire has been particularly prominent in the British trade. The Palmer patents were the basis of much litigation; but in the main were sustained, and they have been supplemented of late years by a number of patents, granted to various inventors, for further carrying out the original idea.

An early inventor in the pneumatic tire field was A. J. Thomas, an American, to whom three patents were granted, under date of March 12, 1889, for a tire to be undetachably held to the rim. The Thomas tire appears never to have been exploited commercially, but his patents were quoted many times in litigation on both sides of the Atlantic to prove priority of invention.

Tire Patents and Litigation.

GREAT BRITAIN.

As has been mentioned, the patents granted to John Boyd Dunlop for a pneumatic tire, though the means of creating a wide interest in this type of tire, and giving a great impetus to the sport of cycling, were otherwise of little importance. The principles of Dunlop's patents having been found to have been anticipated by Thomson, the company formed to exploit the Dunlop invention, in order to utilize their capital, proceeded to acquire other patents, particularly that of Charles K. Welch. The Dunlop tire, by the way, was an inflatable, endless tube, held in place by taping surrounding the tube and wheel rim.

The Welch specification was for "Improvements in rubber and metal rims or felloes of wheels for cycles and other light vehicles." The specification is voluminous, referring to no fewer than 18 drawings, illustrating various applications of the principle involved. The essence of the invention is expressed in the first of the 18 claims, as follows:

I. A rubber or elastic tire having the form of a saddle or arch in section in combination with two wires inserted through the sides of the same for securing it to the metal rims or felloes, substantially as herein described.

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"Hitherto," said the inventor, "the majority of rubber tires used on cycle wheels have been round in section and of small diameter, fitted in grooved rims or felloes, which has not only rendered half of the rubber tire of little or no use for reducing vibration, but has also cut on the sharp edges of the rims or felloes, thus destroying the tire."

The Welch invention was not of a *pneumatic* tire specifically; it was an improved method of applying tires—solid, cushion, or pneumatic—so as to afford at once "easy running, reduction of vibration, and security of the rubbers to the metal rims or felloes." Hence the patent drawings just referred to illustrate every form of tire then known.

It is of historical interest that one drawing "shows a transverse section of a saddle or arched shape rubber or elastic tire constructed according to my (Welch's) invention for covering, protecting and securing tires of wheels which are inflated with air as described in Thomson's patent, No. 10,990 of 1845, and are now in present use." This is the application of Welch's invention to tires having inner air tubes, and it may be said that the figure in the patent drawings relating to this form of tire represents fairly the cross section of the Dunlop-Welch tire in its finally perfected form, as made in England until the expiry of the patent.

The Pneumatic Tyre Co.—the name by which the Dunlop company was first known—early became involved in litigation in defense of the Welch patent. In the case of the Pneumatic Tyre Co. *vs.* Casswell, Justice Kekewich, in February, 1896, rendered a decision sustaining the patent, which was repeatedly reaffirmed in his own and other courts, as new questions arose, a final favorable decision being reached in the House of Lords. Meanwhile the tire gradually became modified until a standard form was reached—a pneumatic tire, consisting of an inner tube, a cover held in position by *inextensible edges,* engaging a specially channeled rim, the patents on which were also held by the Dunlop company. The Welch patent, in the end, was so construed that any device performing the service of his two retaining wires was held to be an infringement—even a tire cover having the edges rendered inextensible by means of solutioned yarns and employing no metallic wires at all.

The New Lamb Tyre Co., of Glasgow, were sued November 4, 1901, in the Court of Session of Scotland, by the Dunlop company, who alleged infringement. The defense was that the tires complained of had been made under a different patent (No. 23,852 of 1897), and that there had been no infringement. In April, 1902, a decision was rendered in favor of the Dunlop company, followed by an appeal, when the decision was affirmed. The court held that the tires had not been made in accordance with the Lamb patent. The edges of the Lamb tire covers were made with

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a number of loose strands of yarn solutioned on to form part of the cover itself, which strands formed a taping to strengthen the edge of the canvas. The defense denied that the effect of such strands was to hold the tire cover in position, but that the cover was held by frictional or other forces. The court, however, decided that the efficient cause of the tire being kept in place was the inextensibility of the edges produced by the hempen strands, which constituted an infringement of the principle of the Welch patent, under which this service is performed by the inextensibility of the wires in the edge of the tire covers.

The Dunlop company brought suit for infringement against Arthur Neal, in a case as follows: A wornout Dunlop-Welch cover was taken to Neal for repairs. It was admitted that he made use of a new lining and a new rubber cover, so that the article supplied to the customer contained nothing that formed part of the original tire cover except the two wires. It was held that Neal had not merely made repairs; he had constructed a new article, and, not having a license to manufacture under the Dunlop patent, an injunction was issued to restrain him from further infringement.

The Dunlop company brought suit against David Moseley & Sons, Limited, and India-Rubber and Tyre Repairing Co., an action in which a decision was rendered by Mr. Justice Swinfen-Eady on December 15, 1903. It was alleged that the first of the defendants named made and sold, and the second sold, tires or parts of tires in infringement of both the Dunlop-Welch and the Bartlett patents, owned by the plaintiff. It was not denied that Messrs. Moseley had made and sold many pneumatic tire covers of the description referred to, but they pleaded in defense that the patents were for combinations of parts, whereas the sale of parts alone—as tire covers—did not constitute infringement. After the case had been strongly contested, the court held (December 15, 1903) for the defendants. Messrs. Moseley were rubber manufacturers and made and sold pneumatic tire covers, but dealing in these apart from the other components of a patented tire was not infringement. They sold such covers for export, but this was a lawful trade. So was selling the covers to persons who had licenses from the Dunlop company to use them.

The court said further: "To say that the ultimate purpose to which the purchasers might put the covers, whether having obtained them for export, they did export them, or whether they afterwards used them in this country, so as to put upon the defendant the burden of ascertaining whether the persons to whom the articles were sold were intending lawfully to use them, would be imposing a burden on them which, in my opinion, the law does not impose." On this case being carried to the

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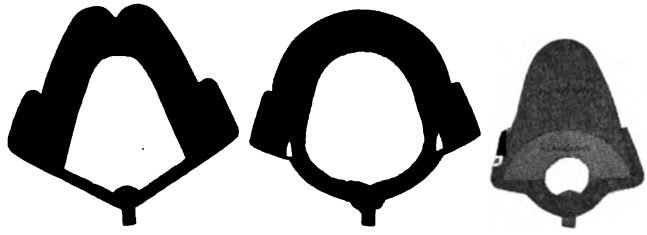
court of appeal, the preceding decision was affirmed, and the appeal dismissed.

The North British Rubber Co., Limited, were sued by The Dunlop Pneumatic Tyre Co., Limited, in 1903, for alleged infringement and violation of license. The latter company purchased from the former, in 1896, the Bartlett patent, under which they had made the clincher tire. At the same time the Dunlop company licensed the North British company to continue the manufacture of the clincher tire, under said patent, on the payment of a royalty of 5 shillings per pair, but stipulating that the North British company should not manufacture any tire which might infringe the Welch patent, also owned by the Dunlop company. In January, 1903, the North British company entered into an agreement with Michelin et Cie., of France, whereby the latter should manufacture such clincher motor tires as the North British company might require for their trade in Great Britain. The French company were not to supply



BARTLETT'S CLINCHER TIRE—EARLY FORMS.

such tires to any other firm in Great Britain, and the North British company were not to have such tires made by any other company, though reserving the right to make in their own works not more than 5000 tires per year. The tire so produced was labelled "The Clincher-Michelin Tyre, Bartlett's patent."

The plaintiffs in this case charged the North British Rubber Co. with violation of the terms of their license in subletting the license to Michelin et Cie. The court, however, held that in this transaction Michelin et Cie. were merely agents of the North British Rubber Co., who are, in the eye of the law, the manufacturers of the "Clincher-Michelin" tires; there had been no assignment of the license held from the Dunlop company. As to the second point involved—the claim that the tires so made had, by the inclusion of features not in the original clincher tire, infringed the Welch patent—the court held that further evidence would have to be presented.

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The decision given by Mr. Justice Byrne was appealed from by the Dunlop company, and affirmed by the court of appeal March 1, 1904.

In May, 1896, The Pneumatic Tyre Co., Limited, commenced an action against the Puncture Proof Pneumatic Tyre Co., Limited, alleging infringement. It was by consent ordered that an injunction be granted against the defendant, when the question came before the court as to the damages to be allowed, in respect of tires made and sold by the infringing party, a decision being reached in February, 1899. The profits which the Dunlop company made were stated to be about £1 per tire. The court, however, made an award on the basis of 2 shillings 6 pence per tire, the amount of royalty then paid by the Dunlop company's licensees.

BARTLETT'S CLINCHER TIRE—1892.

The Palmer Tyre, Limited, sued The Pneumatic Tyre Co., Limited, in the English high court of justice. The plaintiff's case rested upon three British patents, which combined covered the production of a pneumatic tire, and it was alleged that the defendant company were making tires which involved infringement. The patents were No. 4350 of 1889, issued to Amos W. Thomas, for a pneumatic tire; No. 19,411 of 1890, to J. R. Trigwell, for a tire and rim, and No. 4926 of 1889, to John Fullerton Palmer, for an improved fabric. Interest in the case turned upon the third patent, which specified a fabric to be "used in pneumatic tires." This was a fabric comprising a sheet of rubber having embedded therein, before vulcanizing, fibrous threads parallel but not touching each other, two plies of such fabric being arranged one upon the other so that

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the threads may cross at any desired angle. It was held by Mr. Justice Wills (in 1899) that the tires made by the Dunlop company infringed neither the Thomas nor the Trigwell patent, and that the "flexifort" fabric used in the Dunlop tire covers, serving the same general purposes as the fabric of Palmer's patent, was not described in that patent. In "flexifort" the threads were not "embedded" in rubber; they were not kept out of contact; and there was no vulcanization, the threads being kept in place by means of a film of rubber solution between the two layers of threads, the whole being put under pressure. Moreover, the very thing which Palmer patented had had prior use in the factory of Moseley, at Manchester, particularly in making solid rubber tires of layers of rubber having threads embedded therein. This fabric had been patented by Moseley. The court held that the purpose for which a fabric was used was immaterial to this case; the question was whether the "flexifort" fabric was the same as Palmer's, and the question would be the same, whether the fabric was used for a coat, a hose pipe tire, or a tire cover.

Patents were granted in France on the Dunlop pneumatic tire, but were not respected by other manufacturers. In 1895 the Dunlop company seized tires made by a half dozen French concerns—Michelin, Vital and others—and brought suits for infringement of patents. The case involved many technicalities, and a review of the whole field of tire invention, so that the board of government patent experts, to whom the case was referred by the court, did not report until two years later. The finding was against the Dunlop company, the court holding that the principle of the pneumatic tire was anticipated fully in Thomson's invention, patented in France in 1846. This did not prevent the Dunlop company, however, from continuing business in France, where they now maintain a factory.

UNITED STATES.

The Tillinghast single tube tire patent was the basis of a long and vigorous legal contest, which probably was the most important tire patent case in the American courts. A record of the events leading up to the decisive suit relating to this tire appears under the heading "Tire Associations." The basis of the suit was patent No. 497,971, issued to Pardon W. Tillinghast. The case decided was Theodore A. Dodge *vs.* Fred Howard Porter *et al.*, in the United States circuit court, at Boston, the decision being given by Judge Colt, November 14, 1899. The defendants associated with Porter were Francis Flint and Joseph McCune, the three doing business as the Reading Rubber Tire Co., at Reading, Massachusetts.

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The decision sets forth that previous to the Tillinghast tire, the double tube pneumatic tire was in common use. It was to overcome what the patentee regarded as defects in the double tube structure that he invented his single tube tire. Pneumatic tires had been constructed with inner and outer tubes of rubber separately vulcanized, with the joints and parts cemented together after vulcanization. Trouble was likely to be caused, however, by the chafing of the parts in contact, and the cemented joints were liable to separation under the strain caused by the constant flexing of the tire at the tread.

The claims in controversy appear as follows in the specification of Tillinghast's patent:

1. A pneumatic tire, consisting of a rubber air tube, and outer covering, substantially as specified, with the ends of the air tube and other component parts securely united by vulcanization, substantially as described, thereby constituting an integral complete tire.

2. A pneumatic tire, composed of a rubber tube, an intermediate layer of fabric, and an outer covering of rubber, substantially as described, having all its rubber joints and component parts simultaneously vulcanized together, forming an integral annular tire.

The evidence showed that Tillinghast invented his single tube tire, and disclosed it to others as early as the summer of 1890, and that, consequently, his invention antedated the article by Boothroyd, describing a single tube tire, published in *The Cyclist*, in England, on December 3, 1890.

The principal defense was that the Tillinghast patent, in view of the prior art, was void for want of invention. Regarding the various prior patents cited, the court decided in substance as follows: In the construction of a pneumatic tire, Thomson, in his patent of 1847, considered an outer cover necessary for the protection of the inner rubber air tube, but did not conceive the idea of making the inner air tube an integral part of the outer cover. As for the three Thomas patents dated March 12, 1889, the principal feature of novelty consisted in having the tread portion thicker or tougher than the other parts of the tire. It was thought by the patentee that a pneumatic tire could be made out of a single annular tube without any intervening fabric. The only other tire in the prior art at the date of the Tillinghast invention was the Dunlop tire, which was a double tube tire, and manifestly not an anticipation of the Tillinghast device.

It appeared from several American and British patents that it was the common practice, previous to 1890, to manufacture rubber hose composed of an inner tube and an outer rubber covering, with intervening fabric, all vulcanized together. But a pneumatic tire is quite a different

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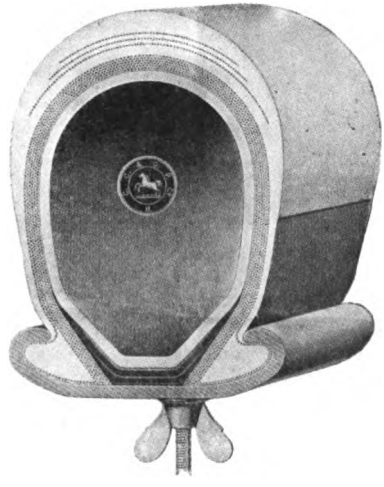
thing from a rubber hose, and each belongs to a distinct art. A rubber hose is a tubing of indefinite length, open at both ends; it is not an annular pneumatic tube forming a tire. There was nothing in the structure or use of rubber hose tubing which afforded any suggestion leading to the production of a pneumatic tire.

G & J CYCLE TIRE—1899.

The decision having been in favor of the plaintiff, the case was carried to the United States circuit court of appeals, where the finding of Judge Colt was affirmed in a brief opinion, the salient feature of which reads:



CONTINENTAL CLINCHER TIRE—1904.

"We are of the opinion that claim 2 fully and correctly represents the invention of the patent, and that claim 1 is too broad to be valid."

Reference to the second claim of the patent, therefore, will give the precise definition of the single tube tire as now under patent protection.

Morgan & Wright sued the Pennsylvania Rubber Co. for alleged

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infringement of patent No. 502,047, of July 25, 1893, covering the method of closing the ends of inner tubes of tires—of the type described as "pinched end" or "flattened end." In January, 1903, Judge Buffington, in the United States court in the western district of Pennsylvania, rendered an adverse decision, holding that the Pennsylvania company had "found a different method of closure, and such mode is not by a flattened end." An appeal was taken by Morgan & Wright, and on December 7 a decision was handed down by the circuit court of appeals affirming the decision of Judge Buffington.

Morgan & Wright had previously sued The B. F. Goodrich Co. for infringement of the above patent, and of patent No. 502,048, in the United States circuit court in the northern Ohio district. In two decrees

SINGLE TUBE TIRE.

by Judge Hicks, in this court, October 15, 1896, the validity of the Morgan & Wright patents was sustained.

At the same time and place another case of Morgan & Wright *vs.* The B. F. Goodrich Co. was decided in favor of the plaintiffs—a suit for infringement of patent No. 490,035, covering the process of making the Morgan & Wright tire sheath on a mandrel.

The patent on a pneumatic tired sulky wheel (No. 494,113) granted in 1893 to Sterling Elliott, and by him assigned to the Hickory Wheel Co., was declared invalid by the United States circuit court at Chicago, and, on appeal, by the United States supreme court, in 1900. The Hickory Wheel Co. sued for infringement of the patent claim: "The combination in a trotting sulky of a frame, shafts, or pole, and seat, and wheels less in diameter than the distance between the shafts and the ground, and provided with elastic tires." The courts held that makers

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of bicycle tires had anticipated Elliott, and that the fact that his tires were to be applied to vehicles of another form did not give to them the elements of novelty.

The United States circuit court of appeals at Cincinnati, in 1899, rendered a final decision in a suit involving priority of invention of a tire fabric, under patents No. 493,220, granted to John F. Palmer, and No. 539,224, granted to R. W. Huss. Delay in granting the patent to Huss was due to Palmer's patent having been declared in interference. After a long contest, the patent office awarded priority to Palmer, and a patent was issued to him. The court declared the *fabric* patents of both parties to be invalid, because, in previously making applications for patents on *tires,* both parties illustrated and described the fabric without at that time making claims for the fabric.

TIRE ASSOCIATIONS.

SINGLE TUBE TIRES.

The American single tube tire patents granted to Pardon W. Tillinghast, then of Providence, Rhode Island, proved to be among the most important in the history of the tire trade. Mr. Tillinghast was a prolific inventor, but reference is made particularly to two patents: No. 486,915, issued November 29, 1892 (application filed June 20, 1892), and No. 497,971, issued May 23, 1893 (application filed September 2, 1892). The latter was the basis of the long continued litigation which resulted in favor of the proprietors of the patents and gave them a monopoly of the single tube tire production in the United States.

It was not until 1895 that Mr. Tillinghast made any move toward having his patents respected. In that year he notified the Pope Manufacturing Co., then owning the Hartford Rubber Works, that they would be prosecuted if they made "hose pipe" tires without respecting the validity of his patents. Colonel Albert A. Pope, head of the company, thereupon purchased the patents. In December, 1905, the Pope company filed a suit for infringement against the Boston Woven Hose and Rubber Co., which, after the employment of able counsel by the defendants, was settled out of court. Papers were prepared for similar suits against two or three other tire manufacturers, who had knowledge of the proposed actions. These parties became licensees under the Tillinghast patents, however, and the suits were not filed.

Shortly afterward the Tillinghast Tire Association was formed, consisting, it is said, of Colonel Pope, of the Hartford Rubber Works; Colonel Theodore A. Dodge and J. Edwin Davis, of the Woven Hose

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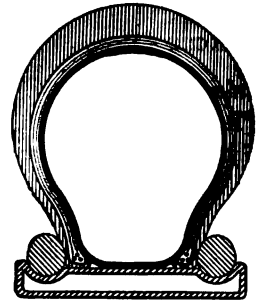
company, and a representative of one other large rubber concern. Afterward the membership was increased and underwent many changes. Upon the formation of the Tillinghast Association the matter of protecting the patents was put in the hands of Colonel Dodge, as trustee. The B. F. Goodrich Co., the Revere Rubber Co., the Hodgman Rubber Co., and some other important companies at once took out licenses. There were, however, many infringers. In April, 1896, it was stated that twenty-five companies were making single tube tires who had not become licensed.

A number of suits for infringement were brought by Colonel Dodge, though only two were carried through—one against the Reading Rubber Tire Co., under the style Theodore A. Dodge *vs.* Fred Howard Porter *et al.*, and one against the New Brunswick Rubber Co., owned by the United States Rubber Co. The result was favorable to the plaintiff, as will be seen on another page.



HARTFORD DUNLOP TIRE.
[Modification of the original fastening, to adapt the tire to motor cars.]

On November 21, 1899, following closely upon the final decision in the Tillinghast suits, The Single Tube Automobile and Bicycle Tire Co., with $1,000,000 capital, filed in New Jersey articles of incorporation signed by Colonel Dodge, president of the Tillinghast Tire Association; L. K. McClymonds, president of the Mechanical Rubber Co.; George Pope, vice president of the American Bicycle Co.; and certain bankers. The Tillinghast Association thus ceased to exist. Colonel Dodge asserted that he had been the owner of the Tillinghast patents for four years, though others had been interested with him in the profits to be realized, including A. A. Pope. At the same time it became known that Colonel Pope's interest in this connection had been acquired by the Rubber Goods Manufacturing Co., through the purchase of the rubber tire factories controlled for a short time previously by the American Bicycle Co., in which Colonel Pope was prominently concerned. The Single Tube Auto-

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mobile and Bicycle Co. continues to exist, with Colonel Dodge at its head, and with an interest held by the Rubber Goods Manufacturing Co., which concern in 1905 was merged with the United States Rubber Co. Thus the latter, which for four years fought the validity of the Tillinghast patents, came to share materially in the profits arising from the single tube tire monopoly.

Another organization formed for conserving the interests of the Tillinghast licensees was the Rubber Tire Association, formally instituted in New York on September 17, 1896, as the outgrowth of a preliminary meeting in May that year of leading manufacturers of bicycle tires in the United States. The chief purpose of this association was to deal with the

FISK MECHANICALLY FASTENED TIRE.

troublesome question of tire guarantees—a feature of the trade that, owing to abuses, interfered very materially with the making of profits by the tire people.

Colonel Dodge was elected president of the association; L. K. McClymonds and George T. Perkins, vice presidents; Kirk Brown, secretary; and George F. Hodgman, treasurer. A standard form of tire guarantee, to be known as the "Association guarantee," was adopted. A meeting in March, 1897, attended by representatives of sixteen firms, discussed the question of adopting a standard size and form of bicycle wheel rim.

At the second annual meeting, in October, 1897, the officers were re-elected and a less liberal guarantee proposed, which, after conference

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with the National Board of Trade of Cycle Manufacturers, went into effect. This guarantee was readopted at a meeting in October, 1898. The Rubber Tire Association continued for some years to deal with the question of guarantees, until gradually the claims made upon the manufacturers for replacements and the like became less onerous, and finally went out of existence. By the way, the association was concerned only with bicycle tires.

At the beginning of 1898 arrangements were made for the more extensive introduction of single tube tires into Europe, through the concerted action of the Hartford Rubber Works Co., The B. F. Goodrich Co., and the Boston Woven Hose and Rubber Co. For this purpose the Single Tube Tire Co. was incorporated in New Jersey, with $100,000 capital. Theodore A. Dodge was elected president; H. C. Corson, of the Goodrich company, treasurer; R. M. Howison, general manager; and Ernest E. Buckleton, general sales agent. Offices were opened in London, where the business was reorganized after awhile as The Single Tube Tires, Limited, and finally merged with the European house of The B. F. Goodrich Co.

G & J TIRES.

The clincher tire in America was developed under the patents granted to Thomas B. Jeffery. These were assigned to the Gormully & Jeffery Manufacturing Co., a bicycle making concern. Later they passed, with that company, under the control of the American Bicycle Co. When this company disposed of its tire manufacturing interest to the Rubber Goods Manufacturing Co., a subsidiary company was formed by the latter to control the Jeffery patents—the G & J Tire Co., incorporated in New Jersey, in November, 1899, with $1,000,000 capital authorized. This corporation still exists, as a holding company for the patents, licensing a number of manufacturers, besides making and selling tires. Latterly the United States Rubber Co. has become interested, through its purchase of control of the Rubber Goods Manufacturing Co.

The G & J tire patents are as follows:

No. 454,115, to T. B. Jeffery, issued June 16, 1891.

No. 466,565, to T. B. Jeffery, issued January 5, 1892.

No. 466,789, to T. B. Jeffery, issued January 12, 1892.

No. 493,160, to T. B. Jeffery, issued April 28, 1896.

No. 558,956, applied for October 6, 1891; issued March 7, 1891, to William Golding, of Manchester, England, assignor to Charles Macintosh & Co., Limited.

The G & J bicycle tires were made originally for the proprietors by The B. F. Goodrich Co., who took out a license for making them also for the trade. On August 28, 1902, papers were filed in the United States

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circuit court in the Southern district of New York, by the G & J Tire Co., against the Diamond Rubber Co., in a suit for infringement of the patents above described. Shortly afterward the Diamond company took out a license from the G & J Tire Co., and most of the leading tire companies have since done the same.

As mentioned elsewhere, tires made and sold in Great Britain by the G & J company were held to be an infringement of the Bartlett clincher tire patent in that country. And the proprietors of the Bartlett tire, on undertaking to do business in America, were successfully proceeded against at law here by the G & J company.

G & J CLINCHER TIRE—1906.

There existed for some time in the United States a G & J Tire Association—a "pool" of the licensed manufacturers under the G & J patents. An agreement was reached as to the volume of production each year, and to the percentage to be produced by each member of the pool. In case any manufacturer exceeded his allotment, a certain percentage on the excess sales was paid into the funds of the association. The management of the pool was in the hands of a commissioner, a lawyer in New York, reputed to have held a similar relation to many other industrial pools. There was also an agreement to maintain prices. One important result of the association's work was the standardization of tire sizes with regard to the weight of load to be carried. The G & J Tire Association ceased to exist on September 1, 1906, but this had no bearing upon the question of the continued payment of royalties. The production of tires planned for the last year was $9,000,000 in value.

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CHAPTER VII.

THE AUTOMOBILE TIRE OF TODAY.

EXISTING TYPES.

TO the ordinary observer automobile tires in use today differ very little in general appearance. Indeed, they are so near together in general contour that they may almost be said to be standardized. There are, however, variations in treads, in plies of fabrics, and, indeed, in shape. In looking at all the types of automobile tires that the world affords they classify themselves on a sort of geographical basis. The beginning of the tire was, of course, in England, through the clincher fastening, but its development—that is, its early development—came about through the success attained by the Michelins in their early attempts to shoe the motor car with something that would allow of speed without vibration. The lead that France held at the first is believed by many to have been maintained ever since. It would look, however, to one who studied the subject carefully that France, England, Germany, and the United States are today practically on a par in the production of good tires—that is taking, of course, the companies that make the best.

The differences between automobile tires made in the countries named, that is the very slight structural differences, are due very largely to the uses to which the tires are to be put. A manufacturer, for example, who knows that his tires are to run over thousands of miles of marvelously good roads, builds a type of tire specifically for that purpose, and that tire will not show up well on bad roads. In the same way one who is producing tires for rough roads builds for that specific work.

In this chapter it is not necessary to go into the various types of rims or fastenings, as those will be treated in another part of the book. Nor is it really worth while to ring the changes on the slight differences that appear in the standard tires. Indeed, the easiest way to show the types of tires now in use is simply to look at the tire in cross section where the very minor differences make themselves appreciated. The illustrations in this chapter, therefore, tell the story, and it is to them that the reader should turn.

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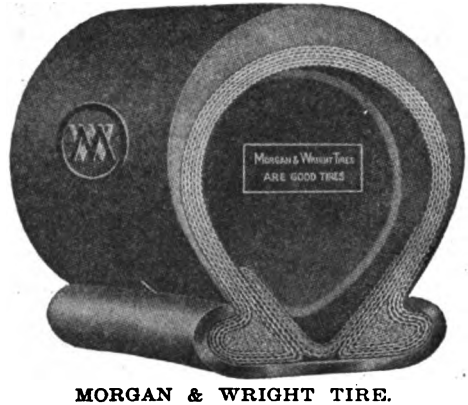
PUBLIC SERVICE PNEUMATICS.

The use of pneumatics on public service vehicles of the heavier type has generally been found either impossible, on account of the great weight to be borne, or disadvantageous on account of low speed requirements or their liability to accident. Trucks and heavy delivery wagons would be out of the question on account of their weight. Small motor wagons and tri-cars are sometimes shod with pneumatics when used to deliver milk or other goods in which the time element is important. The delivery of ordinary parcels would hardly justify the use of pneumatics, except possibly for the advertisement to be gained. The wagons generally used in England for mail and newspaper delivery might well be pneumatized, because quickness of delivery is here important. Careful experiments have been made with pneumatics on fire engines and wagons, but on



MORGAN & WRIGHT TIRE.

account of the liability of accident from objects in the road or from live coals from the engine, the project had to be given up. Automobile ambulances are very often fitted with pneumatics, and they serve the purpose fairly well. Easy riding and speed are both very important in such a case, and overbalance the danger of accident to the tires. Much progress has been made during the last year or two in solving the puncture question, as well as in making tires vastly stronger than it used to be thought they could be made; and as soon as the hospitals and municipal authorities can be brought to realize the recent improvements in this line, it is probable that all ambulances will carry pneumatics.

The greatest future for pneumatics in the public service line is probably for use on passenger vehicles. Tire makers everywhere are trying to fill this demand, and good beginnings have been made in several

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countries. Many of the motor cabs of Paris run on pneumatics, with satisfactory success. Some attribute the extensive use of pneumatics on the public carriages of France to the troubles had there with solid tires, when these were first introduced. Pneumatics have not been so much used on cabs elsewhere, owing to the perfection of the cab tire and to the initial expense in making the change, and for other reasons.

The Germans have perhaps put forth the best efforts to fit pneumatics to motor 'buses. During the last year they have put out several types of motor 'bus tires, some of which are more than 6 inches in diameter, and of a strength able to sustain the heavier 'buses even on country roads and at good speeds. The English have also brought out a motor 'bus tire which is probably the largest pneumatic ever made. Instead of being round, like the German 'bus tires, it is hemispherical, with a flat, ribbed

G & J TIRE.

GOODRICH TIRE.

tread 10 inches wide. Otherwise it is of the usual construction, and when inflated to 100 pounds, it is designed to carry three tons. In America there is made a pneumatic that is expected not only to carry the heaviest motor 'bus, but even trucks. This is round, 7 inches in diameter, with a flat, ribbed tread of the same width, and when blown up to 150 pounds, it is claimed that each tire will bear four tons weight.

None of these giant tires has really gotten beyond the experimental stage, but their makers are playing for vast stakes. During a year in London the public service conveyances of all kinds carry as many people as there are in the whole world. The pleasure going automobile is as nothing to the possibilities offered by the passenger vehicle.

PNEUMATIC TIRE DEFECTS.

With all its merits, the pneumatic tire has its defects. The owner of an automobile who is wholly satisfied with the results he is getting from his tires is a difficult man to find. Tire troubles exist on every hand, and

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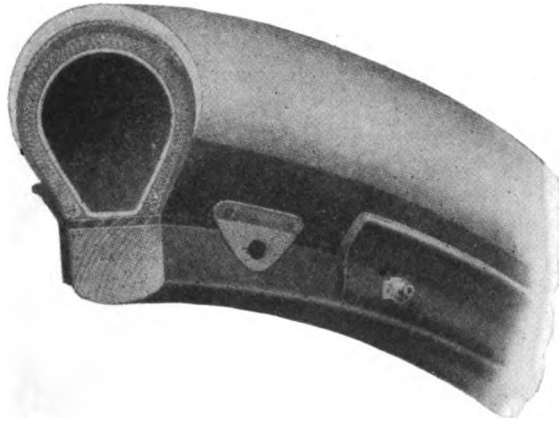
the tire is nearly always blamed, whether justly or not. Rubber tires being comparatively new, the average automobilist has not learned yet to distinguish clearly between troubles due to inherent defects of a tire and those which result from its abuse.

DIAMOND TIRE.

INTERNATIONAL TIRE.

The principal reasons for the unsatisfactory results obtained from pneumatic tires—even when receiving proper care—may be summarized as follows:

(1) The inability to resist puncture; (2) the tendency of treads to separate from the supporting fabric; (3) the fabric rupture due to friction



FIRESTONE TIRE.

between the layers, or caused by excessive strains in encountering obstacles in the road; (4) the difficulty of making a perfect air chamber because of the presence of foreign bodies in the rubber, imperfect curing (vulcanizing) of the rubber, or imperfect connection at the splice or at the valve stem; (5) the fastening lug troubles; (6) the difficulty of

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making lasting repairs at a low cost when any of the above troubles develop.

It is not necessary to include in the list such things as rim cutting; for example, where damage to a tire is apt to be due to the negligence of the driver. Some of the defects here pointed out are inherent—as liability

GOODYEAR TIRE.

to puncture. This tendency will persist so long as pneumatic tires are made of rubber, and so made as to possess a desirable degree of resilience.

HARTFORD TIRE.

TRACTION TREAD TIRE.

Next to punctures, and these are much fewer than the average man would imagine, probably the greatest number of troubles relate to the separating of rubber and fabric, the cause of which may be (1) poor workmanship, regardless of the tire design; (2) faulty design; or (3) careless driving or unavoidable accident. It is of course to be considered

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that trouble resulting from careless fitting of the tire or from excessive loading is not the result of any defect in the tire itself.

The pneumatic tire is composed of fabric and rubber, both materials of little strength as compared with steel, which is most used for tires. Knowing these limitations, designers should proportion the parts to the loads to be carried and the services to be rendered.

A thin tire wall will bend more times than a thick one, for in any wall one side must stretch and the other compress to permit bending. Because of this fact, the thickness of the fabric it is possible to use in a pneumatic tire is limited, and the question is how to get sufficient strength to hold the air and to resist driving and tearing strains, and at the same time afford the proper resilience.

PENNSYLVANIA TIRE.

ELECTRIC TIRE.

As illustrated by Duryea, any one tying together a bundle of sticks would very naturally tie around them the shortest way, and it requires no argument to show that such a string will hold much better than if tied around the bundle the longest way. But all tire makers do not seem to have recognized this fact. It is the main duty of the pneumatic tire to tie or confine a body of air at suitable pressure, and in such manner that it will encircle the wheel, carry the load, and smooth the road. It is the air that is important in the performance of these services, and the tire should be so constructed, not that its rubber and fabric may do this work, but that they may simply insure that the confined air does its duty. The inner tube made of rubber and impervious to air is the first step. The second step is to wrap this with fabric in such a way as to take the strain caused by the confined air in the easiest and safest manner.

Everybody knows that a 2 inch tube will stand a vastly greater internal pressure than a 30 inch tube using the same strength of material, and it should be clear that if the threads of the tire fabric run around the

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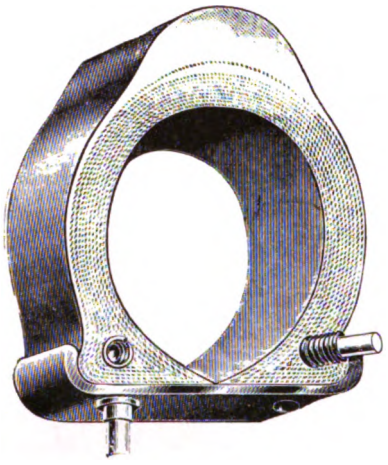
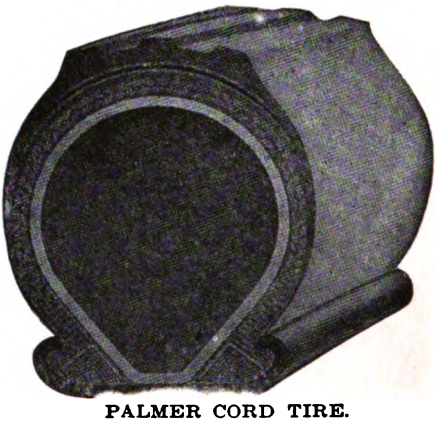


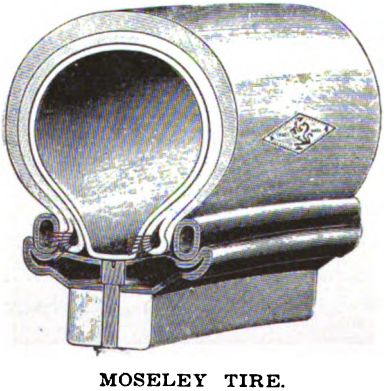
COLLIER TIRE.



PALMER CORD TIRE.

CONTINENTAL TIRE.

NORTH BRITISH TIRE.



MOSELEY TIRE.

MICHELIN TIRE.

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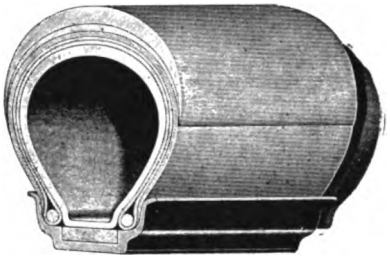
air tube its shortest way, instead of lengthwise, and therefore around the wheel, which is the longest way, they will receive less strain, need be less thick, and will, therefore, give longer and better service.

Clincher tires are frequently run without cement or holding bolts, because they generally have constrictive ability to hold tightly to the rim.

DURO TIRE.



ENGLISH DUNLOP TIRE.

But this is gained at the expense of a very great strain on the fabric lengthwise of the tire. This lengthwise stress serves no purpose so far as confining the air is concerned, but is necessary to hold the tire to the rim, unless other means are provided.

On a smooth road the contact surface of a tire simply flattens against the road surface. In rolling over a pebble the surface of the tire must

HARBURG VIENNA TIRE.

either dent inward to accommodate the pebble or it must lift the entire load and support it on top of the pebble. If the fabric cannot stretch lengthwise, it must take the strain of carrying the load on the small surface exposed by the pebble, with the probable result of a bruised or burst tire. But with a non constrictive tire—one having the fabric well

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stretched crosswise—there is little lengthwise resistance, so that in running over a pebble the fabric threads separate slightly, the tread circumference elongates enough to permit the pebble to sink into the tire, the load is carried by contact with the ground instead of being supported on the pebble, no power is wasted in lifting the load, the vehicle is jolted less and the tire strained less. There is thus pointed out the nature of a not infrequent tire defect and the means for avoiding it.

LIFE OF TIRES.

The life of a pneumatic tire can by no manner of means be predicted with certainty. If tires of a given type and make have run for so many miles, there is a possibility that another set, similar in all respects, may

CALMON TIRE.

last as long, but only a possibility. The best that the manufacturer can do, if called upon for a guarantee, is to undertake to give his customer a tire that will last as long as the average, which involves making repairs or replacements in case any trouble occurs. But probably no manufacturer has any very well defined ideas of average tire life, while as for an individual tire, it may run for thousands of miles, or it may come to grief on the trial trip. Yet the pneumatic tires in general use are more trustworthy than most people would suppose, in view of the above facts; the average motorist goes touring confident of being able to reach his destination safely, and unless there was basis for such confidence the pneumatic tire would soon be discarded.

In dealing with the life of tires, one must take into consideration their proper care, of course. A pneumatic tire will deteriorate rapidly even

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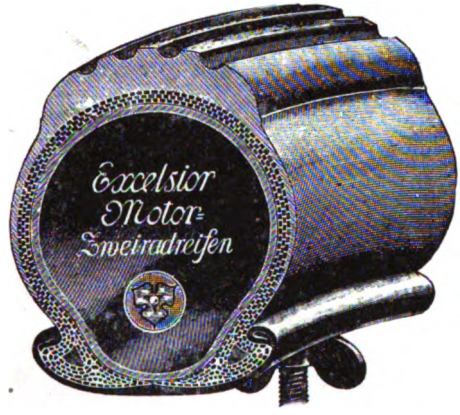
when not in use, if stored under wrong conditions. And improper inflation, careless turning of corners, and reckless running over obstacles in the road are all avoidable causes of shortening the normal life of tires.

A number of manufacturers and dealers who have been consulted express the opinion that a set of pneumatic motor tires, well constructed and intelligently used, and barring accidents, should run for 6,000 miles without requiring the expenditure of a cent for repairs. Recently one company has advertised to guarantee its tires for 5,000 miles. But much higher individual records have been made—or claimed—such as 8,000 and 9,009 miles, and even 12,000 miles for a set of pneumatics. Such figures are of little use for comparison, however, because unaccompanied by data regarding the type of construction, the size as compared with the load, or



HANNOVER GUMMI-KAMM TIRE.

the character of the roads. Still, as said above, they point to possibilities, and afford a further incentive to every tire maker to produce tires of a high degree of efficiency.

There is no record of the maximum distance which it would be possible to run with a set of pneumatics, made with special care, fitted properly, their condition carefully watched, and used only on selected roads. But such record would be of little value. Motorists do not buy tires to study their extreme capability, but to serve them in use for pleasure or business under ordinary conditions. If one can only travel over good roads it may keep him from going to the places he most desires to visit, and he might as well not have an automobile.

What the automobile owner needs to know is that vulcanized rubber is exceedingly tough. It will outlast iron if properly used, but a little unwisdom will promptly bring its own punishment. Hence, in case of

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tire failure the owner should not hesitate to ask how far it may have been his own fault.

Many people have the idea that the life of a tire ends when it has to be removed for repairs. It would not be fair to apply this rule too strictly, however. Oftener than otherwise the injuries sustained by pneumatic tires are capable of being remedied, and the repair may be facilitated by taking the tire from the wheel. A puncture which, if unattended to, would put a tire out of commission, may often be repaired so as not to limit materially the life of the tire. And after the tread has been worn

CLOUTH TIRE.

PETER UNION TIRE.

away, the tire can be retreaded so as to be practically as good as new if the repair man knows his business.

THE IDEAL TIRE.

Now a word or two as to what the tire of the future may be. To begin with, the pneumatic tire of today as compared with the old steel tire, or indeed the earlier types of rubber tires, shows such great advantages that it is in a measure ideal. At the same time, what the tire might be under the most favorable conditions goes far beyond that. For instance, if the pneumatic automobile tire might have its broadest development it

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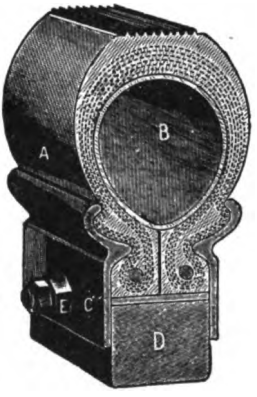
should be cheap—not a possibility today, but who can say what may come in the future? Next, it should be simple and easy of application. Once applied it should destroy nearly all vibration and thus save both the machine and the rider. It should be as light in weight as is possible with safety, both because of the speed developed and the added cushioning effect. It should be equipped with a tread that not only doesn't destroy the roads, but is never a dust raiser, and this tread should be of such a nature that side slipping would be almost impossible.

In its mechanical principle it should be so constructed that side strain, particularly when it is on heavy vehicles, would be absent. It should either be puncture proof or so easily repaired that the puncture would no longer be a bugaboo. Beyond this, the fabric should be of such a nature



LACOUTRE TIRE.

that it could not rot or chafe, while the cover should be sun proof, oil proof, and, in fact, the whole tire so simple that it be practically fool proof. Not that the ideal tire should ever be one that would not wear out, but one that will not give out unexpectedly and one that the automobile owner may safely rely upon to carry him say 2,000, or 3,000, or 5,000 miles under normal conditions, with the absolute knowledge that ninety-nine times out of a hundred no tire troubles will result. It will doubtless be long before many of these points of excellence are reached. But considering the wonderful development that the tire business shows and the triumph of tire makers in the past, it perhaps is not in the realm of the impossible that all of these desiderata may be accomplished.

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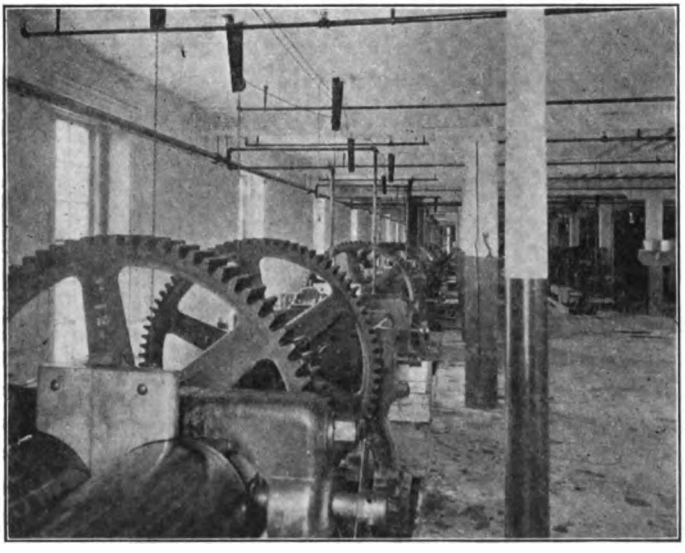
CHAPTER VIII.

THE MANUFACTURE OF CYCLE AND MOTOR CYCLE TIRES.

THE simplest form of bicycle tire is, of course, the single tube, or, as sometimes called, the "hose pipe." That was and is used in the United States more than any other kind. In Europe, however, the double tube—that is, the tire shoe with a rubber inner tube—seemed to appeal to the bicyclist, and the other never got very much of a foothold. This chapter covers the tire itself, the story of the inner tube being told in a subsequent one.



RUBBER MIXING ROOM.

Described in ordinary English, the manufacture of a bicycle tire is an exceedingly simple operation. It was a problem, however, that taxed the ingenuity of the most expert rubber men for a long time; that is, to make the tire commercially. In the earlier days, with the state of the art so young, had they been confronted with the problems of manufacturing huge automobile tires, it is more than probable that the best manufacturers would have believed it to be impossible.

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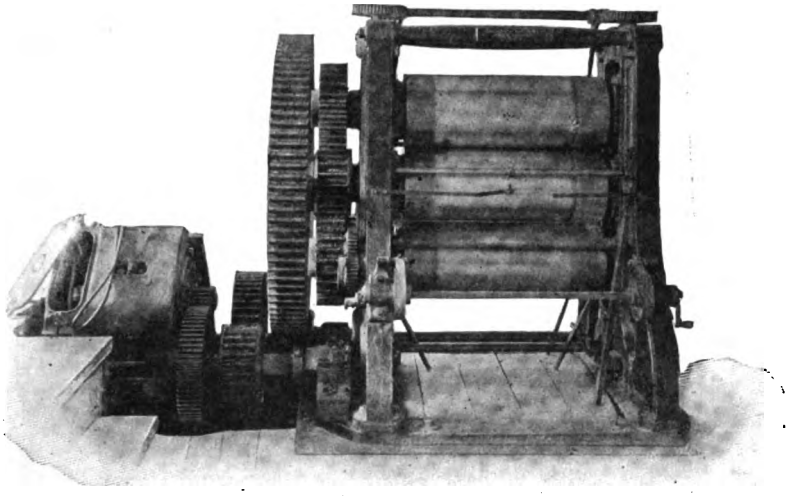
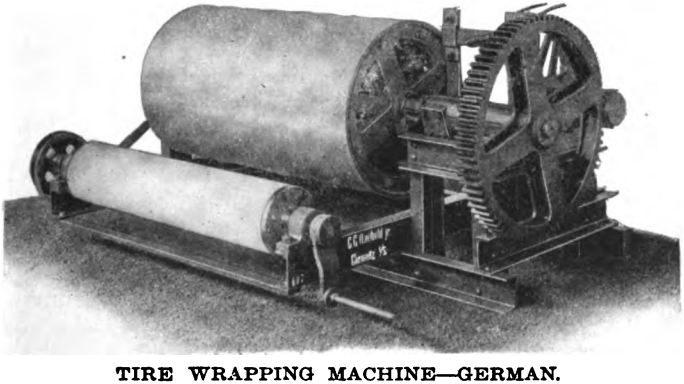


CALENDER FOR COATING TIRE FABRICS.

The bicycle tire consists of two parts, rubber and fabric. The rubber is to give resilience and to hold the air in place. The fabric is to give strength and to keep the rubber from stretching and bursting under pressure. The parts are first formed in strips and cemented and rolled together, being shaped up in the general form of the tire, and later put in molds and vulcanized or baked. In various factories there are a variety of ways by which this manufacturing is done. In some the whole of the work is done by hand. In others there are auxiliary machines designed to cover various processes and to save a certain amount of labor. Before getting entirely away from the beginning of the tire making—that is,



TIRE WRAPPING MACHINE—GERMAN.

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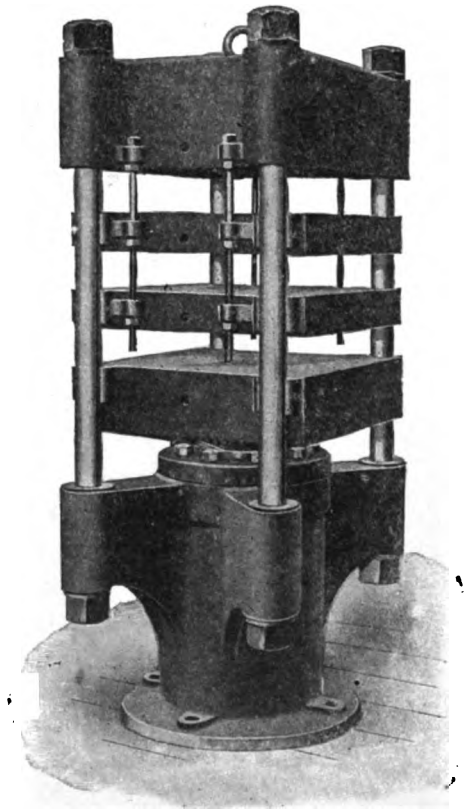
the material—it might be well to say that pure rubber is by no means the best thing for tire covers or tire lining. Long experience has proved that certain compounded stocks give better service, are less likely to tear or wear, and are very much less affected by sunlight, air, or salt water.

When it came to the selection of fabrics almost everything available was tried, silk, linen, hemp, indeed, every fabric that the loom fur-



STEAM PRESS FOR VULCANIZING TIRES.

nished, but in the end cotton was found to be the best all around material that could possibly be used, and long staple cotton of the Sea Island type the best of the cottons. The making up of the strips of the rubber and fabric into a tire—that is, the wrapping—is done by a variety of machines built upon different lines. For example, in 1898, James Bennett Forsyth, of the Boston Belting Co., produced a machine which was exceedingly simple and most effective. This was in brief a drum around which a

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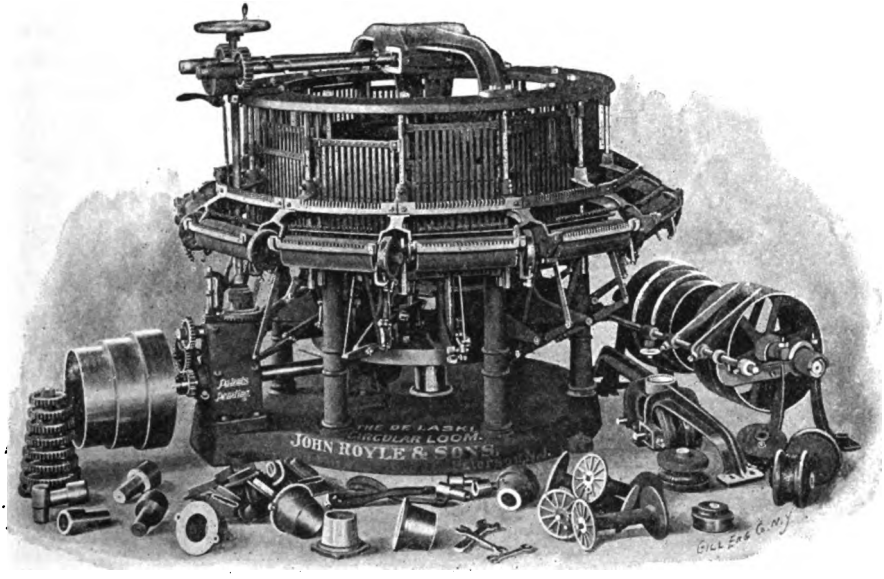
strip of rubber and fabric was placed, the drum then passing through another longitudinally, which was fitted with a multiplicity of what might be called spring fingers that rolled tubes into shape quickly and automatically.

Another machine for the same purpose is the Bridge wrapper, an English invention, which is similar to the hose wrapper in ordinary use, and which does its work very quickly.

Two other English machines are Brainard's tire making machine, which has a capacity for over 3,000 tires a day, and Gubbins's, which is



LOOM FOR WEAVING CIRCULAR TUBES OF FABRIC.

adapted for the covers for double tube tires, and works in connection with a spreader which puts on the rubber in solution.

One of the strongest types of single tube tires is made by the use of a circular loom, which weaves the fabric in a continuous length around a tube of rubber, the cover afterwards being put on by means of a die. In discussing types of auxiliary machines and cycle tire manufacture one must not forget the Haubold enveloping machine, made in Germany. This very quickly and satisfactorily wraps the cover, and so far has been used only on double tube tires. A very little adaptation would, however, render it available for single tubes were the German fashion to tend that way.

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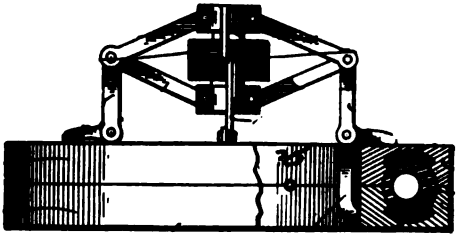
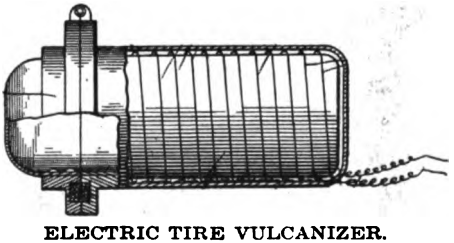


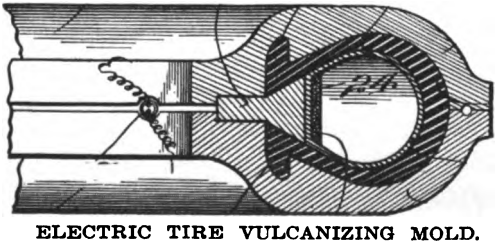
ELECTRIC VULCANIZING PRESS.

Perhaps the most ingenious of all the tire making machines is Doughty's collapsible head machine, which not only forms but vulcanizes covers for the Dunlop type of cycle tire. It will be remembered that this tire was always made by hand; in fact, it did not seem possible to make it any other way, but the inventor named solved the problem and incidentally evolved a wonderfully ingenious and practical machine. Speaking of the same inventor, it is worth while to note another labor saving



ELECTRIC TIRE VULCANIZER.

tire machine that he invented and which is largely used in the Dunlop works in England. This is a quick vulcanizing press in which the tire mold as it is slipped into the press is so set that a jet of steam enters through the tire valve to the interior of the tire and assists in the curing fully as much as do the hot platens that ordinarily furnish the heat in press curing. The curing of bicycle tires by this process takes from 3 to 5 minutes, one man running three presses.



ELECTRIC TIRE VULCANIZING MOLD.

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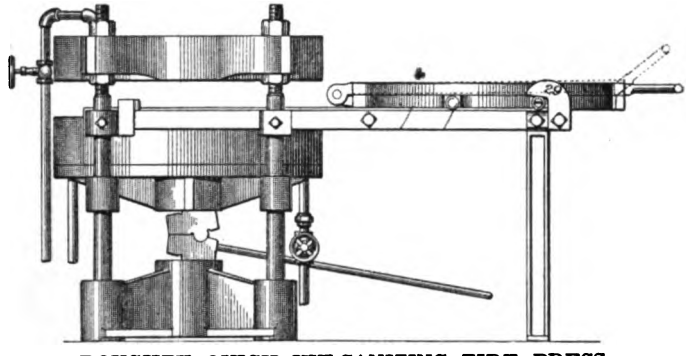
There are many varieties and variations of the ordinary tire mold and tire press. That is, there are single molds chambered to admit the steam and do the vulcanizing. There are nests of molds arranged the same way, perhaps the best of these being the Hayward self vulcanizing hollow mold, for which Charles Macintosh & Co. own the patents. Out-



DOUGHTY QUICK VULCANIZING TIRE PRESS.

side of these special machines there are, of course, regular steam presses that carry all the way from two to a dozen molds operated chiefly by hydraulic power. Where the tires are steam cured the vulcanizers are of the ordinary boiler type, such as are used in the general rubber manufacture.

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CHAPTER IX.

BICYCLE TIRES THE WORLD OVER.

THE history of bicycle tires has not been studied as carefully as it deserves, because the great body of the people are not so much interested in historical development as in actual results. Inventors and a few persons who are students by nature may be interested, but these generally prefer to read their history at first hand, which is in the patent office reports.

The velocipede seems to have been mainly an English invention, developed during the time that the French were busy conquering continental Europe. By the time that the British were becoming tired of velocipeding, the French had become tired of conquering, and gladly took up the less dangerous hobby horse. While the British were developing the locomotive, the French continued with their velocipedes, which they did improve considerably. During the sixties they even established agencies for their hobbies in the other European states, particularly England. The head of their London agency was Thomas Sparrow, an Englishman. Sparrow's sales were not very abundant, so that he had plenty of time to think. He bethought him of the possibility of putting rubber tires on these wheels, and about 1870 he introduced the rubber tired bicycle to the British market. The English were very busy building railroads, ships, and empires, so that not much attention was given to Sparrow. By 1873, however, he had got a following, and he financed a great 1,000 mile run from Land's End to John o' Groat's. Four riders made the trip, the record being 14 days. Sparrow also rode a wheel most of the way with them, taking careful note of the behavior of the different machines, in order to discover and remedy their weak points. Noticing that the rubber tires skidded on greasy roads, he made experiments resulting in the use of leather treads for non skids. He also instituted corrugated treads in rubber tires. He built a cycle factory in London, at 82 Brompton road, S. W., where he did a good business, also inventing a ladies' wheel in 1875. In 1876 the Stanley Cycling Club held its first great show in London, which popularized and greatly improved the new toy. These changes did not affect the tires, however, which continued of the same general design, though leather treads grew rapidly in favor. Most of their tire efforts were expended in making the things stay on,

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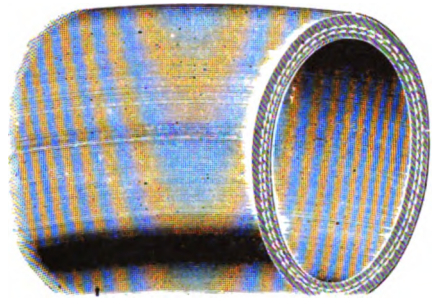
the problem that is ever with us. Cements were generally relied upon, though the sectional solid, held on by rim screws, found some favor.

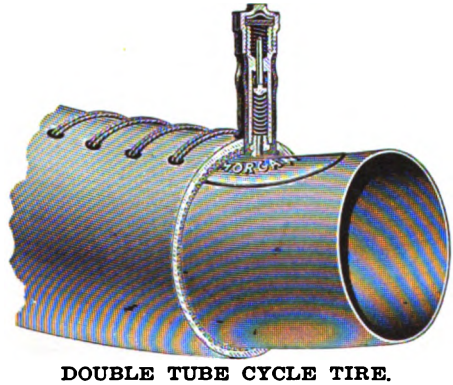
In 1881 the "Indestructible" tire came out, representing a distinct improvement in tire making. This tire was vulcanized to the channel, the rubber adhering to the metal so closely that it was impossible to tear



SINGLE TUBE CYCLE TIRE.

out the tire. The fatal weakness was that repairs necessitated sending the wheel to the factory. The sectional solid, mentioned above, was held on by a steel strip running through the tire, this strip being engaged by screws through the rim.

The application of pneumatic tires, successfully accomplished in the early part of 1889, was, of course, the great turning point in bicycle his-



DOUBLE TUBE CYCLE TIRE.

tory. The year 1890 saw the introduction of the detachable, wired on tire, and inventions came so thick and fast that by the end of 1890 British pneumatics had taken on the essential characteristics of the cycle tire of today. To be sure the thing was still primitive enough, having only one layer of fabric, generally made of linen rags. Moreover, the cycling papers had forecast future developments in tire making, most of which

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have, indeed, come to pass, and the various ills peculiar to balloon tires had been pretty well diagnosed. The necessity for thorough inflation was being dwelt upon, a pressure of 40 pounds being recommended. Two types of self inflating tires had been patented during 1890, valve improvements and various puncture proof schemes were in order, safety valves had been suggested, and attempts were being made to prevent the rubber tread from peeling off the canvas.

The early development of the pneumatic was practically confined to Ireland, though the Welch and other noted inventions were English or Scottish in origin. The Irish racing teams, with their pneumatics, went over to England and won all the races so easily that the English were actually shamed into cultivating the same type of tire. The cushion tire, first brought out by Macintosh in 1884, had been very popular in England, but this now practically disappeared, and the pneumatic held the field. Boothroyd, in Ireland, brought out a cushion tire that was practically a single tube pneumatic, and at the same time Tillinghast, in the United States, brought out the single tube, or undetachable tube tire, which afterwards became so famous.

If England and Scotland were slow to take up the Irish invention, the United States were still slower. In 1891 the League of American Wheelmen racing board were still fighting the pneumatic, and racers who used "balloon" tires had to stand a heavy handicap. It was the deeds of Nancy Hanks in a "bike" sulky that really taught the Americans the virtues of the pneumatic tire. The business increased very rapidly when it did begin, and in 1891 the American consumption of rubber for bicycle tires was estimated at 1,000,000 pounds, including all types. The weight of bicycle tires then averaged about 4 pounds, whereas racing tires later came to weigh as many ounces. In 1892 the estimate for American tires was 2,000,000 pounds of rubber, the tires averaging about 5 pounds apiece. The American tire business was still small, however, as compared with that in Britain, where there were nearly 1,200 bicycle factories running, and some of the tire factories were using some 15,000 pounds of rubber a week.

During 1892 the American market offered the following types of cycle tires: Solid, cushion, inflated (single tube), Boothroyd cushion, and the regular pneumatic (double tube). There was, as yet, no national division in types, such as later developed, and the New York Belting and Packing Co., who were the first to make bicycle tires in the United States, made and offered all known types, including detachable pneumatics. The Sweeting Cycle Co., in their 1892 catalogue, said of the tire trade of 1891: "The year has not been without surprises. Foremost among them comes

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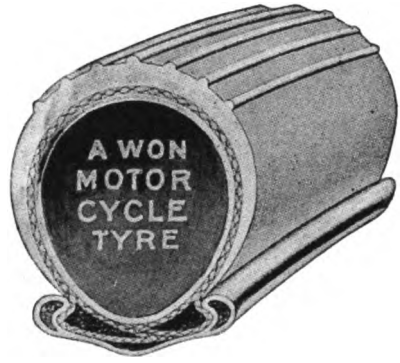
the pneumatic tire. At the beginning of the year it looked as if the whole business would be in single hands; but the utter worthlessness of the first tires put on the market brought American brains into play, and now the manufacturer who does not have his own pneumatic tire is in the minority." This tendency for bicycle builders to make their own tires increased rapidly for several years, until each leading make of wheel was thought of as having a certain kind of tire. Thus what is now known as the G & J tire was identified with the "Rambler" bicycles; the "Victor" wheels were equipped with a special make of tire, and so on. Each bicycle had its own enthusiastic admirers in those days, and they were prejudiced against any tire put out by another firm. Morgan & Wright were about the only independent concern making tires exclusively, and



BARTLETT CLINCHER CYCLE TIRE—ENGLISH.

they exerted a tremendous influence on tire construction in the United States, inventing the butt ended and quick repair types, and keeping popular attention fixed upon the subject of tires. They came in time to make some 70 per cent. of all the bicycle tires used in the States.

Nevertheless, it was not the Morgan & Wright tire, built by tire specialists, but the Hartford tire, built by a bicycle manufacturing company, that ultimately triumphed in America. The reason for this lies partly in the love of the United States men for fast riding and partly in their mechanical aptitude and ability to handle tools. While the Europeans were riding 2 inch double tubes, held on by wires in France, and beaded edges in Germany, and all kinds in England, the tendency in the United States was wholly toward single tubes of ever smaller diameters, it having been found that a small single tube pumped hard is the fastest of all for road use. The Tillinghast Tire Association, which controlled the manufacture of all single tubes, finally produced an article which represents the high water mark in cycle tire making, in resilience, cheap-

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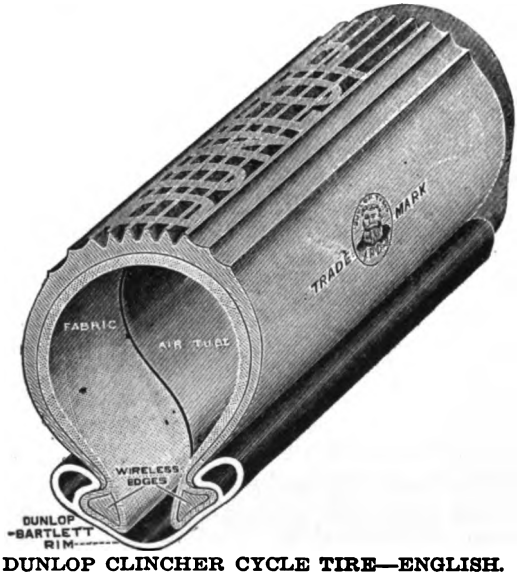
ness, beauty, and speed. For anybody with deft fingers, it is also the easiest of all to repair, and this fact appealed strongly to the American.

Though the American single tubes invaded Europe and found hosts of friends, on account of their many virtues, the question of their repair could never be mastered by either the British or the Continentals. Could the Tillinghast association have set up repair shops at convenient places throughout Europe, the single tubes might have swept the country, as they did here. Even in spite of hostile tariffs, they were sold in Europe cheaper than the home made kind. There were only 200 single tube tires made in the United States in 1891, while 1,250,000 were sold in 1896. In England the single tube was cultivated during the early years, the



DUNLOP CLINCHER CYCLE TIRE—ENGLISH.

Avon Rubber Co. being most successful; then too the W. & A. Bates Co. were using plugs for their tires in 1892; so that the repair of single tubes by the regulation method has been known in England as long as in America. The British are tolerably quick with tools, and the reason that the double tube tire survived in the Islands is probably to be found in the prevalence of hedge thorns on the English roads. These hedgethorn pricks are easily stopped with the thick repair fluids which were later developed here in America; and had the English known of this method early in the day, the single tube might have had a different history there. There are no hedges in France, and the avowed reason of the failure of the single tube there was the inability of the Frank to repair them. An-

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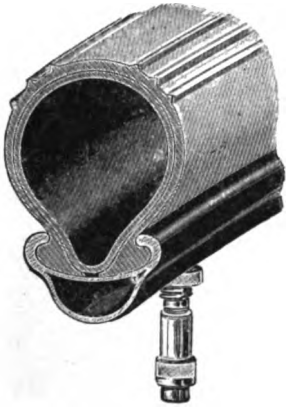
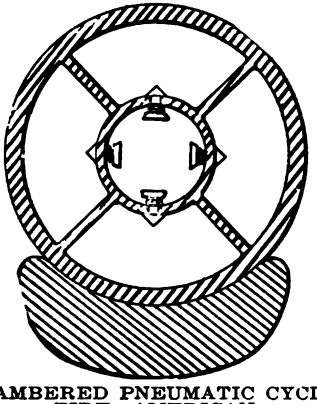
other reason was probably due to the great influence of the Dunlop company there, no less than to the great growth of the Michelins. Even to this day, the wired on tire is the dominant bicycle type in France.

The Germans seem to have had as much trouble as the French with single tube repairs. They lagged slightly behind the French in taking to the wheel, and when the Continental and Berlin-Frankfurter companies

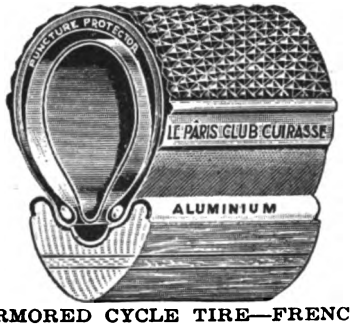


PALMER CYCLE TIRE—ENGLISH.



CHAMBERED PNEUMATIC CYCLE TIRE—AMERICAN.

undertook the manufacture of cycle tires, they were wholly under British influence. The Continental company made their racing tires of the single tube type, but these were very expensive and unsuitable for road use. The French racing tires were a kind of cross between single and double



ARMORED CYCLE TIRE—FRENCH.

tube. They had the appearance of single tubes, but they were so made that the outer casing could be unwrapped, exposing the tube. Where the casing levers overlapped, they were loosely cemented, so that the lap could be pulled open. One reason why Dunlops have always been the standard cycle tire in France is that the Darracq and Clement companies, now so famous as automobile makers, have generally controlled or rather

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monopolized the French bicycle manufacture, and these manufacturers very early agreed to use only Dunlop tires on their wheels. This agreement had a powerful effect upon the independent French bicycle makers, who practically had to follow their lead and use Dunlops. As for the Michelin house, they have never done so much in bicycle as in automobile tires, and have been committed to the clincher. The clincher tire has never been popular for bicycles outside of Great Britain, though the Palmer and other great English companies have held to this type from the beginning.

LARGEST OF ALL CYCLE TIRES.
[American "Vim" tires, 12 feet in diameter.]

One great trouble experienced with the single tube has been its tendency to become "porous," as it is called, due to some injury to the inner tube, allowing the air to travel through the fabric until it found various outlets through surface cuts in the tread or around the valve. It generally required a good tire repairer to meet this contingency. Various anti leak fluids were also put on the market for this purpose, these being viscous substances, which, when injected into the tire, filled up the slight breaks or flaws in the inner tube by oozing into the fabric, where it dried and stopped the air passages. "Porousness" was the source of much vex-

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ation to single tube users, before they properly understood the cause and its prevention. Sometimes the cause was a defective repair, due to the failure of the mushroom plug to cover the hole properly on the inside. Sometimes it was caused by a nail, which, besides puncturing the tread, jabbed into the tire next to the rim. The best preventive, in a case of this kind, and, in fact, in treating all single tube punctures, is to squirt some cement down through the tread upon the lower part of the tire next the rim. The thick rubber solution would generally mend any ordinary rupture of the lower part of the inner tube, and thus prevent porousness. The "Vim Special," made by the Boston Woven Hose and Rubber Co., aimed to prevent this same trouble by having two inner tubes, separated by the fabric plies. If the "inner inner tube" became broken, the "outer inner tube" was expected to catch the fabric leak.

Puncture proof bicycle tires have never been popular, mainly because of their inherent slowing effect. Various puncture proof devices were suggested in England in 1891, but the first tire of the kind actually marketed came from France. The inner tube was reinforced within by thin rubber flaps, which overlapped. If a thorn pricked the tube, it was supposed that when it was withdrawn the position of the flaps would be slightly disturbed, so that the hole in the flap would not come over the hole in the tube. It really did work pretty well for awhile, though some leaking went on until the tube was patched. In England the "Self-Sealing" tire has had a good deal of favor for several years. The tube is reinforced within by a strip of soft, compressed rubber, the compression tending to close any hole automatically, the instant the piercing object is withdrawn. In the United States the idea has generally been worked out along the lines of the Chase tire, which contained a layer of "felted" cotton between the tube and fabric.

Though there is probably as much inventive genius in America as in Britain, still the more radical departures have never thriven so well, nor have "freaks" in tire construction hung on so tenaciously as in Britain. The English are very persistent; and while the American patent records are as full and rich as the British, the tire market in England has always been the most interesting of all. It is there that we find the greatest number of curious rims, fastenings, treads, fabrics, and types of tires. The tubeless tire, for instance, is essentially English, as is the turnbuckle fastening, the metal clincher (represented in the Grappler tire), and, for that matter, practically everything else that is characteristic in tire making, except the single tube type. The single tube tire is often called "tubeless" in England, though this is inexcusable in one who professes to clearness in his terminology.

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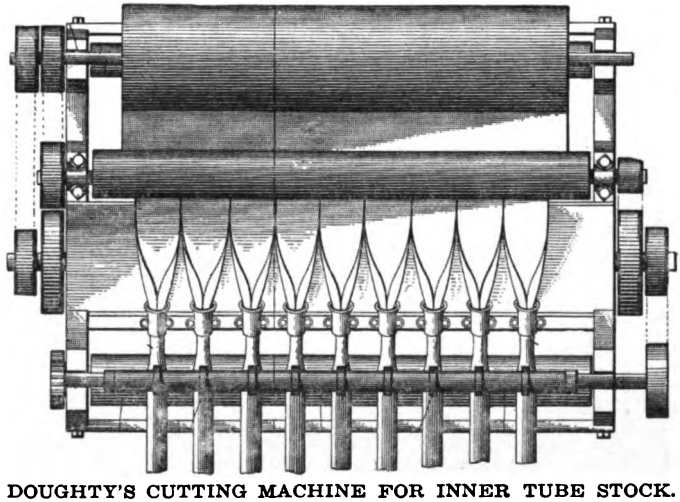
CHAPTER X.

INNER TUBES.

THE basic processes for preparing rubber for shaping up before vulcanization have already been described, and they are practically the same for the manufacture of inner tubes as for any other articles made of sheet rubber. The difference in handling begins with the great sheet of rubber, run in several plies to reach the proper thickness, when it reaches the cutting room. There it is cut in strips of the width necessary and wrapped round and round an aluminum mandrel,



DOUGHTY'S CUTTING MACHINE FOR INNER TUBE STOCK.

and the whole put in the vulcanizer and baked. This in brief is the process. There are, however, ingenious machines that accomplish this.

For example, one machine, which takes a strip of rubber from the cutting table over an endless belt, solutions the cut edges, dries out the surplus solution, presses the edges together, hammers the joint, and passes the finished tube along, where it is slipped upon a mandrel, and later cured.

There is also the Doughty machine, which takes in the whole broad sheet, cuts it into strips, and then runs them through another machine provided with a die for drawing the edges together and a reeling device

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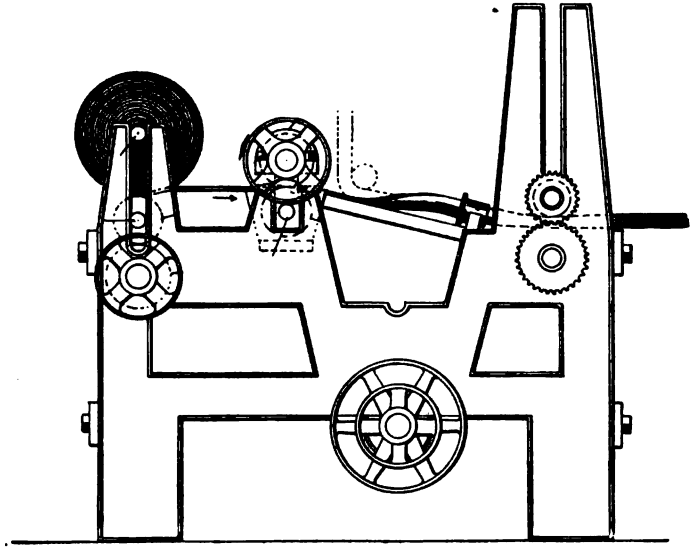
for carrying off the finished tube. Even beyond this there are variations; some lapping the joints, some butting them, some adding a reinforcing strip, and so on.

As a whole the inner tube compounds are practically the same; that is, what may be termed pure stock, the dark colored ones being sulphur cured, the red ones containing antimony sulphid in place of sulphur, which not only cures them but gives the red color to the stock. Of the two colors, which is better no man has yet been able to decide; a good red tube is as desirable as a good gray one.

THEORY AND TYPES.

To quote an English tiring man: "The most vital part of a tire is the inner tube, from which the compressed air is forever struggling to



DOUGHTY'S MACHINE FOR MAKING INNER TUBES.

escape." It is unfortunate that the air should be such an unwilling captive and servant, but it is to its unsuccessful efforts to escape, that the pneumatic tire owes its peculiar excellence.

An inner tube will stretch considerably, and if not restrained would balloon and burst, while if it is pinched or nipped under a lug or against a flange, the unequal strain will certainly tear it. It will not easily rupture unless unduly strained; but when it is pricked or cut while stretched, the best rubber tears like wet paper. The tube is in the tire for one very definite purpose—to prevent the air from leaking out. Confining strength,

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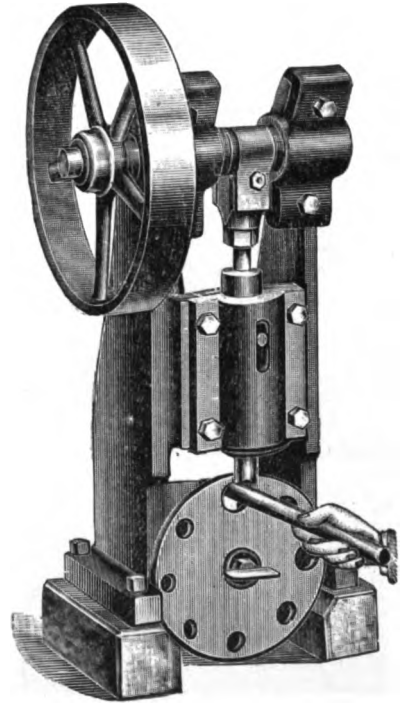
resistance to road wear and to the entry of sharp objects, or any other features must be supplied by other means. The air in a motor tire is at a pressure equal to that at which steam engines run, and it will leak through the tube or even blow it to fragments, if it gets the slightest chance. Motor tubes are made thicker than bicycle tubes, partly to enable them to hold a round shape, for convenience in putting into the tire. The extra thickness does not enable it to hold air any better, and it does not add any material strength. On the other hand, this greater thickness



DEWES'S HAMMERING MACHINE FOR CLOSING JOINTS IN INNER TUBES.

makes the tube harder to repair and proportionately more expensive. The custom of making motor tubes smaller in diameter than the shoe is a distinct disadvantage from every technical point of view, although a small tube is more easily inserted and is less likely to be pinched than a large tube.

An inner tube is a simple proposition, and the principle is of such ancient application that it could not be patented. They were clearly in Welch's mind in 1890, and were probably used some months earlier in the Dunlop tires. By 1892 they were in universal use, and beginning to

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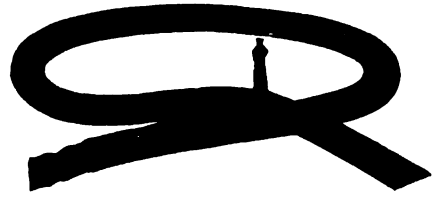
differentiate into the detachable tube, used in double tube tires, and the vulcanized-in type, used in single tube tires. In 1893 the detachable tubes were cut in two and the ends sealed, this method making for greater convenience in repairing, owing to the construction of the casings at that

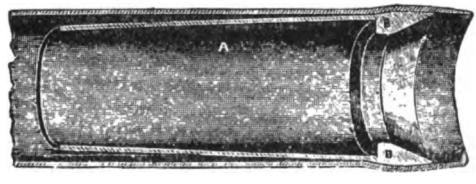
HANNOVER GUMMI-KAMM INNER TUBE.

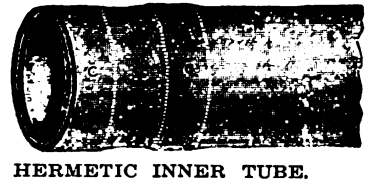
time. This double ended detachable tube originated with Morgan & Wright and had a great popularity, until it was displaced by improvements in the detachability of tire covers, which permitted the use of endless tubes. Then came the popularity of the hose pipe tire, in which the



MECHANICAL FABRIC INNER TUBE.

tube was permanently vulcanized. The motor cycle then recalled attention to double ended detachable tubes, since the tube could not be otherwise taken clear of the machine, on account of the practical impossibility of detaching the rear wheel from the frame. The strain on motor cycle





HERMETIC INNER TUBE.

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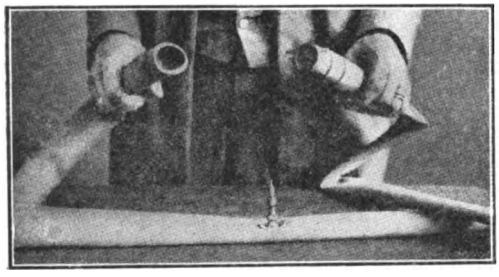
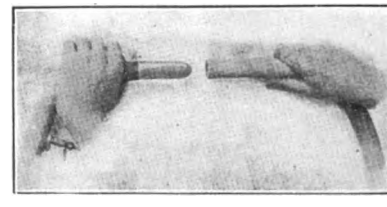
and tri car wheels is much greater than on bicycle wheels, and certain weaknesses developed at the sealed ends, which would burst, unless the ends were lapped just right. Numerous inventions consequently arose, designed to strengthen the ends and yet prevent too great solidity, resulting in "dead ends." It is also undoubtedly best to have the ends join after the tube is inserted, so that there are a great number of patented devices for interlocking or joining the ends of inner tubes. Several of these methods are illustrated—some of them held together by hooks and eyes, by buttons, expanding ball and socket joints, and other devices.



MICHELIN INNER TUBE.

The puncture bugaboo has probably called forth a greater amount of thought than any other feature about pneumatic tires. It has always been known that rubber stretched and compressed behaves very differently toward cutting and puncturing. Solid rubber tires and the covers of pneumatic tires are always so made that the surface rubber is under compression, to prevent its cutting. Many persons have also attempted to apply this principle to inner tubes. As early as 1892, Bourdon and Douris, two Frenchmen, got a patent for an inner tube made twice as large in diameter as the cover, so that the tube was wrinkled and folded, even after inflation. The theory was that this loose tube would not puncture, but would be simply displaced by the point of a nail or other sharp object. Though these expectations were too sanguine, the claims were repeated in part by several other inventors. Humphrey, of California, patented a similar tube in 1895; and though the puckers or folds were not expected to resist puncture, it was thought that when the tire was again inflated, the chances were that a flap would be brought over the hole and thus shut in the air.



CLIFTON INNER TUBE—ENGLISH.

Several British firms, among them being the Sirdar and the Scott tire companies, still utilize this principle in part. The tube is made large enough to fill the whole space within the shoe without stretching. To keep it out of the way of the lugs and tools, the tube is vulcanized so

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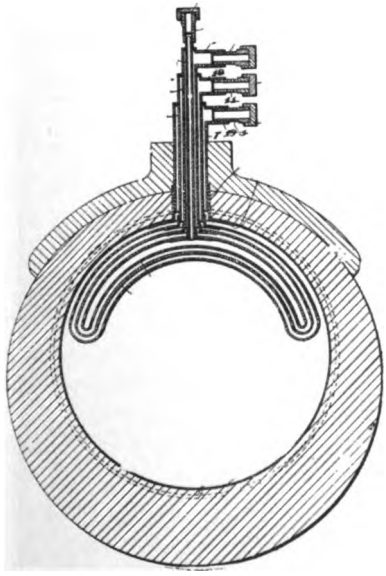
that it is normally folded in upon itself, in section like a "U." During inflation this loop rounds out, and is thereby said to slightly compress the rubber. This does not make the tube puncture proof, though the air escapes very slowly from a hole, the tube being to that extent self sealing. Some French and American tubes are also infolding, but only for the purpose of holding the tube away from the danger of pinching or being injured by the applying tools. One other long established English tire company makes a specialty of self sealing air tubes, having the upper part of the tube lined with a layer of soft rubber under compression. The result is that punctures are automatically closed without appreciable loss of air.

Another puncture device is embodied in various modifications of the diaphragm tube principle, in which several reserve tubes, each with its separate valve, lie within the principal tube. In case the ordinary tube is pricked, the cause is first removed and one of the emergency tubes is then blown up. Some tubes made on this principle have four or five reserve tubes in them. They have not wholly come up to expectations, however, because the puncturing object frequently reaches through and jabs holes in the lower part of the tube, especially when the tire runs flat. Such an experience would ruin all the reserve tubes at once. Morgan & Wright's quick-repair device was rather better, since a puncture of the



MAGOWAN MULTIPLE INNER TUBE—AMERICAN.

SIRDAR INNER TUBE—ENGLISH.

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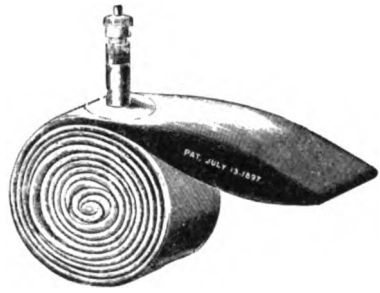
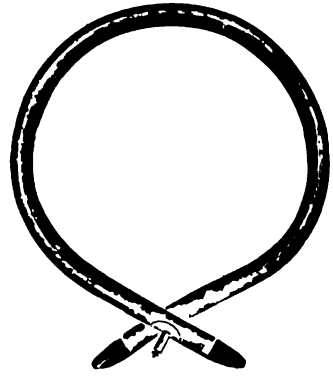


NEWTON INNER TUBE—AMERICAN.

inside flap in the tube did not impair its efficiency. When cement was introduced and the flap pressed up against the puncture, the chances were that the puncture in the tube and in the flap would not exactly coincide.



GOODYEAR INNER TUBE—AMERICAN.

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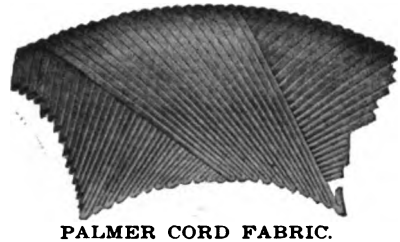
CHAPTER XI.

WHEN Dunlop, of Belfast, first made pneumatic tires, he found that the strength of the rubber could not be relied upon; so like a good Irishman, he lined his thin walled tires with Irish linen. Imitation being the strongest instinct in man, his Scotch and English copyists naturally also used linen fabrics, and so did the Americans, when they began to make pneumatic tires. Later, when unexplainable difficulties arose in connection with their tires, they delved into the inner workings to find out the matter. Some prominent tire makers of America seem to have been the first to fix the blame upon the kind of fiber instead of the kind of weave, and they soon discarded flax for cotton. They



PALMER CORD FABRIC.
[Showing position of cords in outer cover.]

figured that flax threads chafed each other more than did cotton, and also suspected that the flax might be less resistant to the action of heat during vulcanization.

Whatever the true explanation, cotton duck seemed to work better than linen, and Sea Island cotton best of all. Sea Island cotton is three or four times as long and strong as the upland kinds; and though even then it is far inferior to hemp or flax in strength, it seems to be more pliant. Whether as a reward for their ingenuity or for some other reason, these New York mills speedily monopolized the manufacture of American tire fabrics, and also taught others how to follow their lead. Since that time cotton has been the standard material for tire fabrics, though ramie has been tried, and silk has been used to some extent for bicycle racing tires, especially in England.

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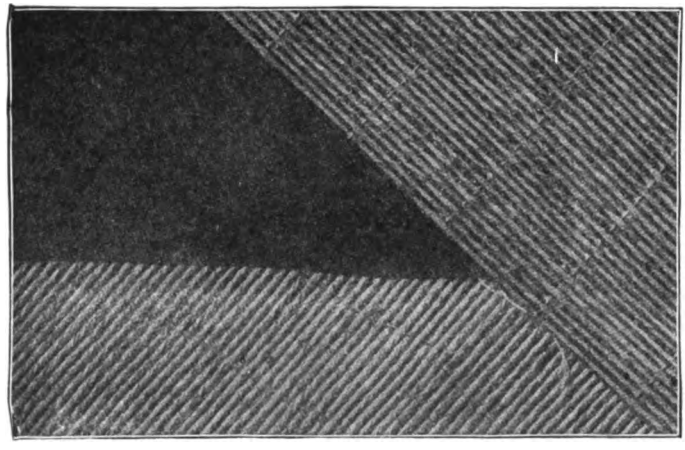
There is little positive proof that cotton is intrinsically better than linen in tire construction, and the natural supposition would be that hemp is the ideal material for this purpose, being the strongest and softest of all the true fibers. The longest Sea Island cotton measures perhaps two inches, while hemp fiber grows 10 to 15 feet long, and is stronger than

PALMER CORD FABRIC.
[Showing two layers of cord.]

cotton almost in the same proportion. Flax fiber is about 3 feet long, nearly as flexible as cotton, and is many times as strong. As for the tendency of hemp and flax to absorb and hold water, they can be rendered practically proof against decay by treating them with ordinary antiseptics. As for chafing in the tire, due to the continuous bending,



G & J THREAD FABRIC.
[Showing the way the strong threads cross each other, with rubber between the layers.]

there is no sound reason for believing that cotton behaves any better than linen in this respect.

The most probable reason for the change is that the linen manufacture is best understood in Ireland, while the English and Americans best understand cotton, and are best equipped for it in machinery and or-

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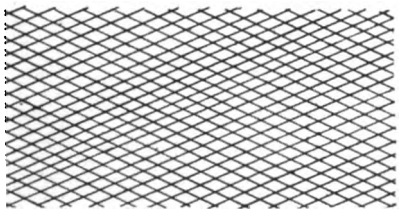
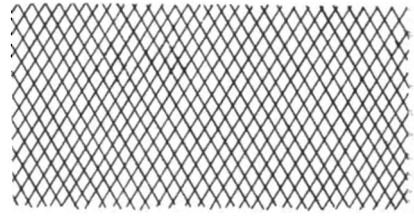
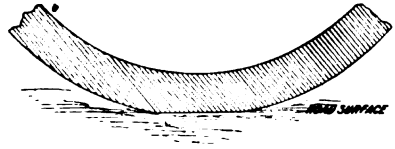
ganization. The American mills, that first used cotton for tires, were regular cotton mills, tire fabrics being only one branch of their business; and it is but natural that they would try to use cotton for the purpose. It was the same with the English, and as Continental tire makers generally get their tire fabrics from England, the whole world used cotton.



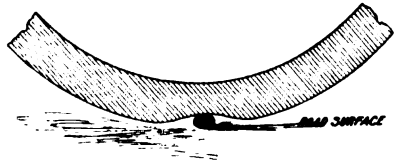
TIRE FABRIC—CONSTRICTIVE WEAVE.



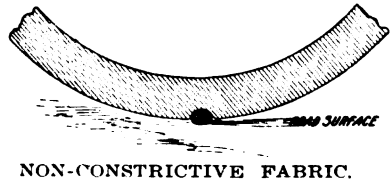
TIRE FABRIC—NON-CONSTRICTIVE WEAVE.



SNUG WOVEN TIRE FABRIC ON A FLAT SURFACE.



CONSTRICTIVE FABRIC WITH TAUT OR STRETCHED TREAD RUNNING OVER A PEBBLE.



NON-CONSTRICTIVE FABRIC.
[The tread yields and stretches and absorbs the pebble without straining the fabric or jolting the vehicle.]

The American mills were exceedingly faithful and thorough in their researches and efforts. They welcomed every idea in that line which was presented to them, and it is said that they made 500 or 600 different kinds of tire fabrics for their customers, embodying every kind of thread or weave that they could hear of. When the bicycle business became small,

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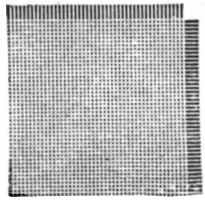
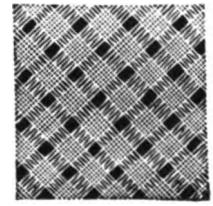
and the automobile business arose, it was the great rubber companies who had made cycle tires that supplied the tires for the new industry. It was soon found, however, that an automobile tire is more than a big bicycle tire, and many new firms sprang up to meet these changed conditions.

The bicycle tire makers succeeded in covering the field of fabric making very thoroughly, developing pretty much every kind now used.

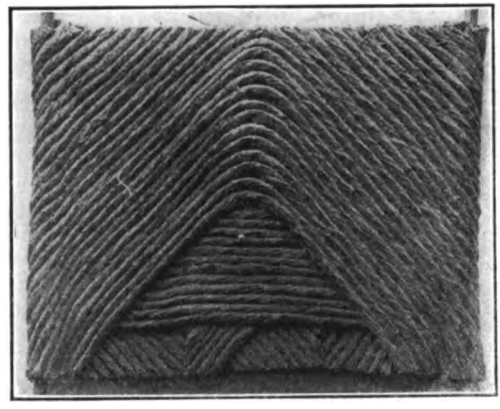


ORDINARY CLOSELY WOVEN TIRE FABRIC.



GOODYEAR RIVET FABRIC.

Some bicycle tires had only one thickness of fabric, and when several plies were used, they had not to contend with the fearful side strains to which motor tires are subjected, and which tend to tear the rubber tread



IVES'S FIGURE 8 FABRIC.

from the canvas or separate the different layers. There was, therefore, no particular need of special fabrics, ordinary frictioning being sufficient to hold the layers together.

The reason why the duck in rubber tires is cut on the bias, with the threads diagonal to the tire, is now quite generally understood. When the first high wheeled bicycles were made, the wire spokes ran radially to the rim. The power being applied through the hub, the wheel devel-

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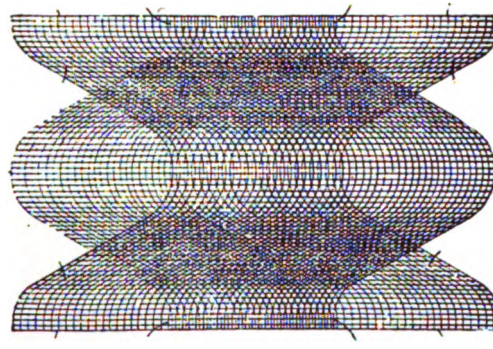
oped a twisting motion around the hub. The hubs were then made with the spokes running out at a tangent, and this trouble ceased. When pneumatic tires were first used, the canvas was naturally laid straight; but since the power had to be delivered through the tires, it was soon found necessary to have the threads of the tire fabric run at a tangent with the rim, so that they would be in the line of strain in driving or checking the wheel. Considerable in a bicycle tire, this driving strain became vastly more important in the motor tire.

Most of the double tube tires are held to the rim by some fastening; but the single tube tire depended, for its hold, upon its own tendency to grip the rim. This necessity led to the development of the constrictive fabric, which was laid on diagonally, with also a considerable lengthwise stretch. The result was, that when the tire was blown tight, the swelling



WELCH CURVED CROSS THREAD WEAVE.

of the sides tended to shorten the inner diameter of the tire, making it cling tight to the rim. Without this principle, it is probable that the single tube would not have been a success. In a horse drawn vehicle, whose wheels only need to support a weight, with neither driving strains nor a tendency to creep, it is not necessary to build the tires with the threads running diagonally, unless it be to prevent puckering under the bottom, where the diameter is smaller. Where resilience and supporting strength alone are required, there is no need for any but the crosswise threads. This is the case on the front wheel tires of bicycles and automobiles, which only carry weight and resist side strains. The driving wheel tires, however, should have the fabric threads tangential to the rim, to stand the driving strain.

The study of driving strains led to many developments in tire fabrics. The ordinary square woven canvas, tightly woven, with the same number of threads in each direction, has been most generally adopted, on account

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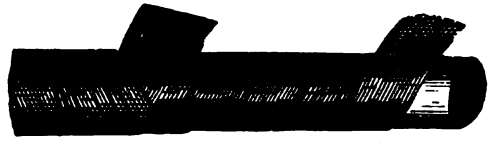
of its great durability, though it is poor in resilience. When extremely resilient tires are wanted, such as for bicycle racing and electric automobiles, the square weave cannot be used. It being recognized that every longitudinal thread sacrifices resilience, these threads are only used at intervals to hold the cross threads in place for frictioning. The "Cleveland" tire was said to be actually made with only cross threads, laid parallel and frictioned. In weaving, the threads are necessarily crimped to some extent where they cross, and are apt to chafe, unless the fric-



PALMER THREAD FABRIC.

tioning is perfect. Hence the effort to do away with the longwise threads, so that the others can take the strain while straight. The Palmer cord tire, in England, has always followed a method similar to this, though several threads are first combined into cords, carefully rubbered and flattened. These cords, lying parallel and crossing each other at such an angle that they are tangent to the rim, lie nearly in the line of strain, which falls upon all of them equally. In the United States a G & J tire is made with a thread fabric, there being only an occasional warp thread to hold the woof in place. The development seems to be rather in this direction, where great resilience is wanted.

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CHAPTER XII.

TIRE RIMS AND FASTENINGS.

THE use of the word Rim, in connection with automobiles, calls up a rather curious evolution in the wheelwright's craft, and at the same time acknowledges the indebtedness of the motor car to the bicycle. The needs of the automobile have thrown a considerable strain upon the wheelwright's vocabulary, and this last has not exactly made good, by the way, though it has proved more resourceful than our sister

GRAPHIC SKETCH OF ENGLISH QUICK DETACHABLE RIM—THE MOSELEY.

languages in Europe. Here, as in many other respects, we have reason to congratulate our mother tongue for its fertility. The French and Germans have been able to keep up tolerably well by transliterating our terms, they being generally able to break our compounds into their syllables and translate them a syllable at a time.

The regular wagon wheel has a tire, which is a simple steel band, and a rim, which is also called a felloe. Beyond that are the spokes, hub, and so on. When the solid rubber tire supplanted the iron tire, to give this genial member a chance to stay on, it seemed necessary to cut a channel in the rim. Soon, however, a separate iron channel was invented to hold the rubber tire on. Next came the inflated tire, resting in a hollowed rim of wood or metal. The word felloe was lacking in

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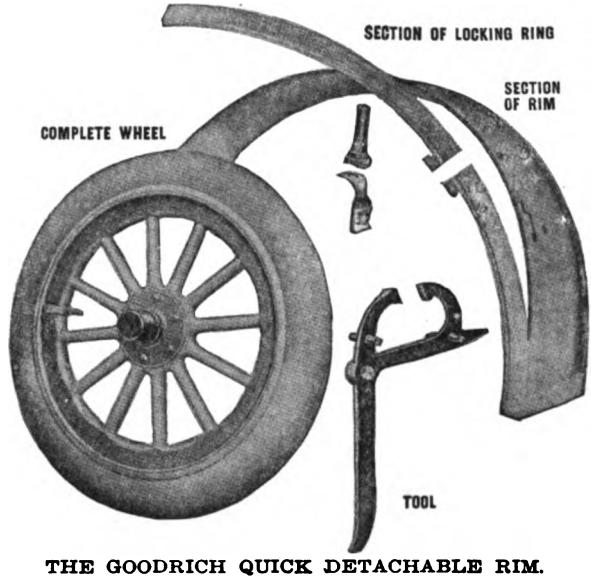
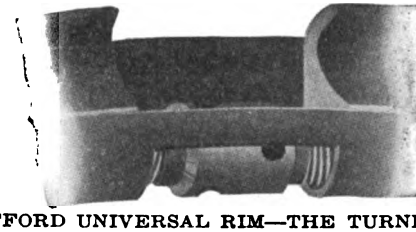
the wheelman's vocabulary, and rim was heard only in connection with the question of wood versus metal. The clincher tire followed, which, demanding a rim of a peculiar shape, attracted general attention to rims; and from that day to this, the word *rim* has been used more than



THE GOODRICH QUICK DETACHABLE RIM.

all the rest of the wheel vocabulary put together. Rubber tires had always needed rims, but now the rim was the thing of things. Pneumatic tires and wire wheels went together as a matter of course, the spokes fastening directly to the rim, after which came the fashion for wooden automobile wheels, with a felloe upon which the rim had to be fastened. Then



HARTFORD UNIVERSAL RIM—THE TURNBUCKLE.

came a new rim which had one flange detachable; since which time flanges have rivalled rims in importance. Then came a rim which could be detached from the felloe bodily. Incidentally, for the strength of the wheel, it was found necessary to shrink a steel band upon the felloe, so that the

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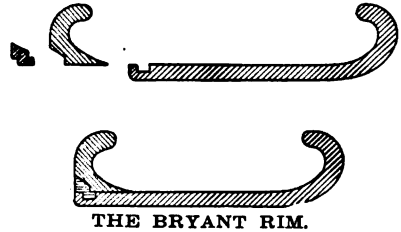
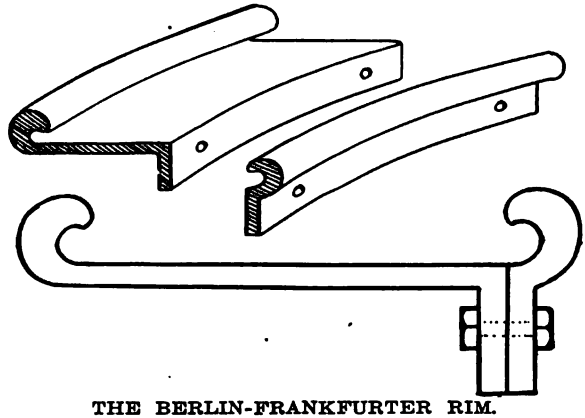
rim carrying the tire might be easily slipped on or off. Thus the wheel, with rim detached, finally got back its original shape; but only for a moment, for the next step was to sweep away the felloe and band, and attach the detachable rim directly to the spokes.



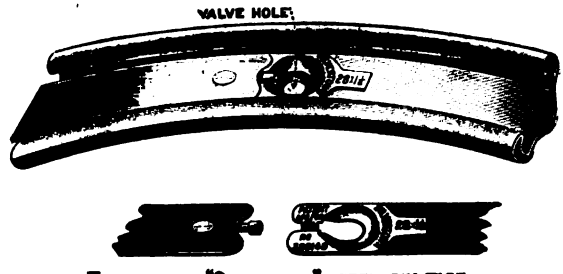
THE BRYANT RIM.

As has been shown elsewhere, the early tire patents related chiefly to rims. Those of the first solid tires had to have the channel cut out of the iron by machinery, making them very costly. Anybody could put in the



THE BERLIN-FRANKFURTER RIM.

tire. Then a method was found by which the rims could be rolled into shape from a flat strip, making the channel very cheap, as compared with the tire. This became the standard channel, or at least the standard



FASTENING OF "SILVERTOWN" STEEL RIM TAPE.
SILVERTOWN FASTENING.

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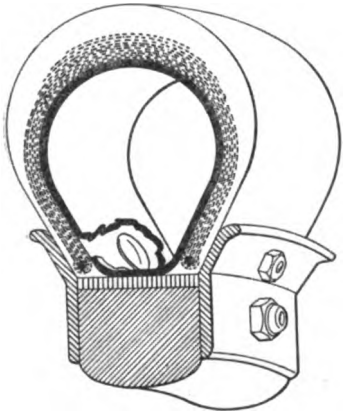
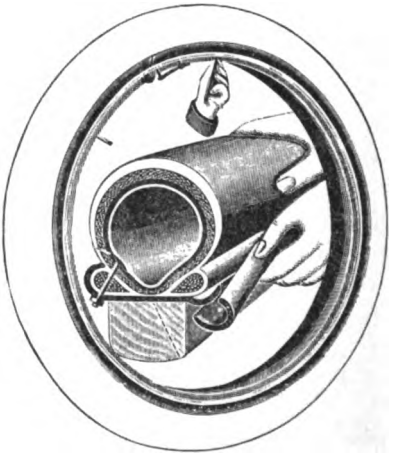
for solids. The tire would occasionally pull out, however, and the British conceived the idea of bending the flanges inward, so that the base of the tire was both compressed and gripped, something like a clincher rim. This method is still used largely in England, and it has lately been revived in America for solid or cushion tires to be used with or without internal



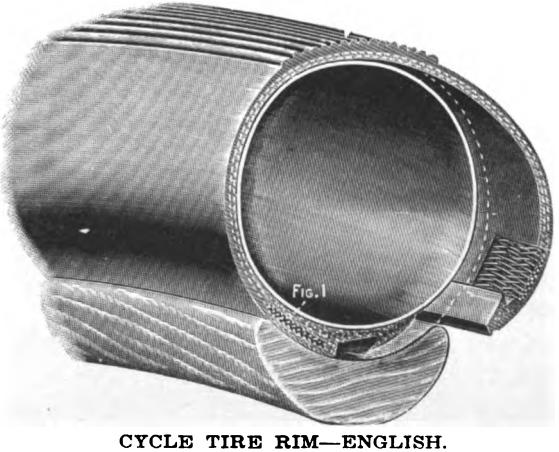
THE PALMER RIM AND FASTENING.



PADGET'S DETACHABLE RIM.

cross wires. The American method of holding tires on by internal or side wires, now used everywhere, revived the standard channel rim.

The wired on type of tire is generally considered the first detachable pnuematic. The principle of the Dunlop-Welch tire was very ingenious. The wires in the edges of the cover were both rigid and smaller in cir-



CYCLE TIRE RIM—ENGLISH.

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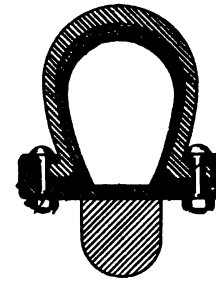
cumference than the sides of the rim in which they lay, so that the tire could not be forced off bodily, unless the wire was broken. The center of the rim was hollowed out all around slightly deeper than its height above the resting place of the holding wires; so that when the wired edges were pinched together into the hollow of the rim, the edges of the cover could be lifted over the sides one at a time. It was found, however, that in the case of motor cars, the side strain, which was unknown in bicycling, was liable to force the wired edges into the hollow of the rim, thus detaching the tire while running. The inventors then set to work and succeeded in producing a channel rim with one side or flange removable. It was next found possible to make the rim flat bottomed, instead of concave, so that there was no more danger of involuntary detachment, so long as the wires and flanges held. This improvement probably makes a very perfect form of attachment,

INTERIOR FASTENING DEVICE.



KOKOMO RIM AND FASTENING.

and this style of rim is rapidly coming into use for both solids and pneumatics.

The clincher rim, whose development is commonly associated with the North British Rubber Co., was probably the most sensational feature ever brought into the vehicle world, and from the time of its introduction until the present time, it has been the standard rim for pneumatics. It is probably used today on 98 per cent. of all automobile and motor cycle tires. For some years after the principle became known, this rim appeared in a variety of forms; but for nearly five years it has been standardized by agreement among makers the world over, so that it now appears only in one shape, which is familiar to everybody.

It seems well right here to clear up some misconceptions commonly held with regard to the clincher principle. The clincher *hooks* to the rim, and nothing else. The hooking may be made more secure by the pressure of the air inside, and it is made still more secure by the use of lugs; but

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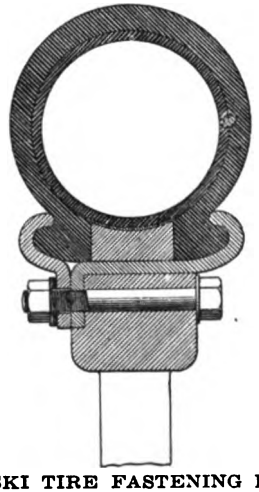
the essential and only principle is that of a continuous hook, represented by the bead.

This happy thought did not burst upon the world all at once, and it is questionable in even the North British company for tracing the evolution back too far. Elsewhere are exhibited the typical Bartlett tires and rims between the years 1889 and 1895; and it is very apparent that there is no attempt at a hook, while the patents all insisted upon the necessity of inflation. In the 1894 model the edges of the cover show a pronounced enlargement, and the rim flanges are slightly bent inward; but there is no possible good in the thickened cover edge, except to render this edge inextensible. This inextensibility of the edge is also increased by the presence of several thicknesses of canvas. The rim is also hollow; and to show that this was



DE LASKI TIRE FASTENING DEVICE.

considered essential, we quote from the North British 1894 catalogue the directions for detaching the tire:

"Deflate the air tube thoroughly and *press the edges of the cover well down into the hollow of the rim* opposite the valve tube, holding them in this position with the left hand. By working around the rim with the right hand, and keeping the edges well in the hollow (as in the sketch), the edges of the cover go easily over the edges of the rim, when the fingers can be inserted and passed around until the whole cover is removed."

It is evident that the whole scheme is identical with that of the wired on tire, except that the inextensibility of the cover edge is gained in a different way. In other words, there was no clincher idea involved, because the clincher tire *hooks on.*

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At this time (1894-95) in the United States, the G & J tire, held on by hooking to the rim, was becoming very popular, and might have become more so, had it not been owned by the makers of a particular bicycle. The G & J bicycle tire and rim were then made exactly as they are made now, with a wood rim grooved to receive the double bead, and held on by these hooks, assisted by air pressure. When deflated, the cover could be pulled off by simply disengaging the hook beads, the cover edges being free to stretch all they wanted, though there was no need of this, and no tendency thereto.

It has already been shown that the Bartlett tire and rim were patented in the United States, and that the G & J tire and rim were patented in Great Britain. The two rivals invaded each other's territory, sued each other for infringement, and each gained his suit. They accordingly combined ideas, blended them, and produced that famous hybrid, the real clincher rim.

The clincher rim, as everybody knows or should know, is a simple steel channel with the flanges curled inward, forming a hook which catches a corresponding hook on the tire. Whether the tire be inflated or not, the cover cannot be taken off until the bead is disengaged from the rim clinch; and if the bead were inextensible, the tire could not be taken off at all. The principle is that of a hook, and nothing else; and though, through failure to recognize this fully, neither the hook on the rim nor the hook on the tire has been made pronounced enough to hold the tire securely, the use of lugs has fairly remedied this defect. The use of lugs, troublesome as they are, is an open admission that the clincher, as now made, is not complete.

There is another group of rims, which are commonly called the mechanical fasteners, though the term is rather awkward. These form a residual class, including every kind of holdfast rim except the simple crescent or channel, and the various modifications of the Dunlop and the clincher types. The inventions in this class are very many, indeed, both because the idea is peculiarly fascinating, and because the reward for success would be very great. Most of these ideas, however, have never got beyond the patent office, and while many of the others have attracted more or less capital, and several have actually been marketed, the trade at present knows very few mechanically fastened tires, and some of these are misnamed. Nevertheless, this type has many merits. It has been found to be tolerably easy to make a tire stay on all right, so long as it is blown tight, and most tires depend to some extent upon inflation, in order to fit well. The greatest trouble, however, has been experienced from running on loose tires, on account of the greatly increased tendency

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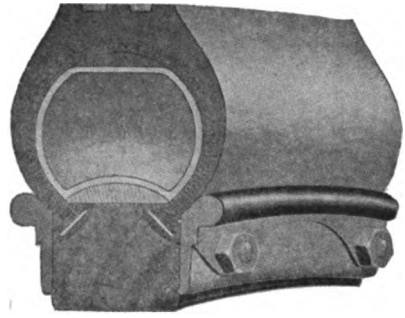
to creep or to blow off bodily. Unfortunately they are apt to come off at the very time they are most wanted to stay on. Running on a flat clincher is certain destruction to both tube and shoe, while the mechanically fastened type will suffer much less, and sometimes only the tube is hurt.

The best known types of mechanical fastening are probably the Palmer, in England, and the Fisk, in America. Each, however, is allied



PALMER CORD TIRE RIM.

with the controllers of the clincher patents through force of necessity, owing to similarities in the general principle. Creeping and blowing off the rim are manifestly impossible; and though the through bolts are undoubtedly troublesome, it can hardly be said that the detachment of a

PETER UNION FASTENING.

clincher held by lugs is any less so. The use of lugs with clinchers is, as said, a concession to the principle of mechanical fastening; but still the use of lugs is so nearly universal that the detachable clincher flange has been seriously handicapped by the practical impossibility of using lugs with this device.

We also illustrate several other types of mechanical fastenings, some of which are well known to the trade.

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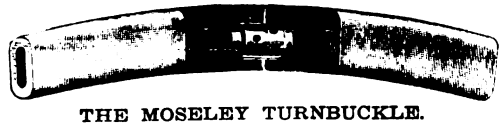
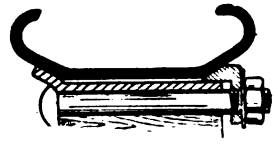
The detachable flange idea seems to have grown up in Great Britain, developing from the wired on fastening. It was not applied first to the flange, however, but to the holding wires themselves. The Welch patent requires, as we have seen, a tire cover whose edges are made inextensible by some means, generally by the insertion of an endless wire. In order to attach or detach this cover, it was necessary to have a hollow rim. This gave some trouble, however, so the makers of the Scottish tire equipped their covers with tires whose circumference could be regulated by means of the turnbuckle principle, the ends of the wires being connected by a screw with right and left threads. They were thus



THE MOSELEY TURNBUCKLE.

enabled to make their rims flat bottomed. Welch had himself suggested the use of turnbuckles on his wires.

This was a very clever idea, and had only one fault, the effects of the water which entered through the opening in the cover edge. The idea was kept in mind, however, until the rise of the motor car threatened the extinction of the wired on principle. The turnbuckle idea was then applied to the flanges, instead of the holding wires, and this improvement immediately restored the wired on type to popular favor. Not only that, but it set in motion a train of thought that resulted in untold inventions of



THE VINET DETACHABLE RIM.

detachable flanges all over Christendom; until now there are some who declare that it will eventually supersede the mighty clincher itself. To be sure, most of the present detachable flanges are made for clincher rims; but the clincher must have lugs, and the growing tendency is to make the detachable flanges reversible, so that they will fit the Dunlop also. Thus, detachable flanges eventually mean tires held on by internal wires, whether they be solid or pneumatic. In the case of solids, the sensational invention of the side wire principle temporarily restored the rigid channel; but the wire mesh base, the grid, and the vulcanized-on holdings have again turned the tide toward the detachable flange channel.

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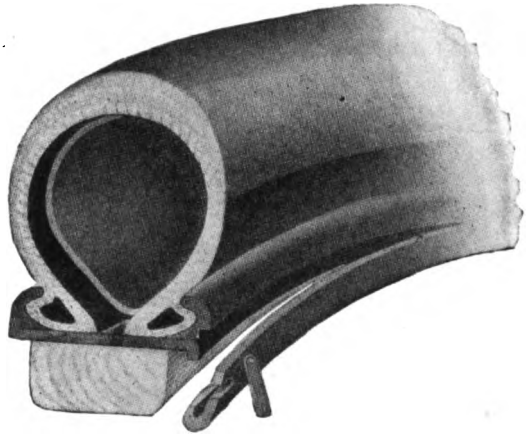
It remains only to speak of the detachable rims, which have lately come to the front in connection with racing cars. Many persons think that this principle is newer than it really is. As a matter of fact, the invention is much older than the use of it. The earliest to attract consid-



DIAMOND MARSH RIM.

GOODYEAR UNIVERSAL RIM.

erable attention was the Cave quick change rim, an English product. This did not have much sale, however, on account of its fitness for racing, which is not popular there. In France, where racing has assumed such prominence, the idea was taken up eagerly, as soon as it became known.

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The M. L. rim has been on the market nearly a year, and the Michelin, Vinet, Lousteauneau, and Houdet types followed within the next few months, all of them being substantially alike, and all intended for pneumatics.

In England, the Stepney spare wheel really embodied the essential principle, and this rim has been on the market for years. In Germany, detachable rims are much used for solid tires, on account of Metzeler's revival of the vulcanized-on method of fastening tires. These tires are now vulcanized upon a steel band, and the whole slipped or forced over the regular wheel band. Other firms are also making use of this same principle, slightly modified. One German firm makes a channel with rigid flanges, but the whole rim breaks at one place, so that it can be inserted within or under an endless solid and then locked. The spokes fasten directly to this channel rim by screwing into sockets. In the United States, the Christie rim, lately brought out, has also done away with the felloe, the spokes fastening directly to the rim, upon which the tire is already mounted and inflated. If the spoke fastenings prove sufficiently secure, this will undoubtedly prove to be the best detachable rim on the market, because it allows the use of valve and lugs, without in any way interfering with the attachment or weakening the rim, which is more than can be said of the French rims. In the Michelin rim, for instance, the felloe must be cut half through, in order to admit the valve stem, while in the Vinet rim a special valve is needed, which does not project below the rim. The whole idea of detachable rims is still comparatively new, however, and in time they may become adaptable to touring cars as well as to racers.

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CHAPTER XIII.

THE TIRE PUMP.

THE beginning was with the bicycle hand pump, held in one hand and worked with the other, followed by the foot pump, held by the foot and worked with both hands. A few strokes of this were enough to fill a bicycle tire. The principle of this pump was that of a simple cylinder and piston. When the motor car came in, this hand pump became wholly inadequate, for when geared for high pressure it took a long time to fill the tires. When geared for volume, it did the first filling easily, but the large piston would not deliver the necessary pressure. There later developed a pump that was compound, or two speed geared.

Nearly all automobile hand pumps are now made compound, or double geared, combining a large and a small cylinder, the large one driven by the down and the small one by the up stroke. Each has its own check valve, and either may be disconnected. For use in the shop or barn, it is customary to use a simple acting pump, but with a lever instead of the up and down stroke, making it much more powerful, and bringing the most leverage to bear at the point of greatest pressure. These are sometimes double acting, but with cylinders of the same size. It is claimed that with them a 5 gallon tank can be pumped to 60 pounds in 3½ minutes. Five gallons is about the capacity of the average auto tire. A 36 by 5 inch tire at 90 pounds pressure will require about three times this time to fill. The largest hand pumps will deliver about 36 cubic inches at a stroke. At high pressures they are very irksome, indeed.

It is becoming generally recognized that the power pump is the thing, especially those driven by the car's engine. As some of the pump makers advertise, it is foolish for a man on pleasure bent to exhaust his strength on a pump, when he has 40 horse power lying idle under the bonnet. In most shops or barns, too, a stationary engine is needed for several purposes, and for this there is made a power pump which can be driven either from a countershaft and belt or by a crank and flywheel. This pump has three cylinders, of rather small dimensions, so that both volume and high pressure can be delivered. Their cost is from $70 to $80, and by reversing the valves, the pumps can be used to create a vacuum. The cylinders are oiled and watercooled, for use in continuous running, such as storing high pressure in large tanks. Besides filling

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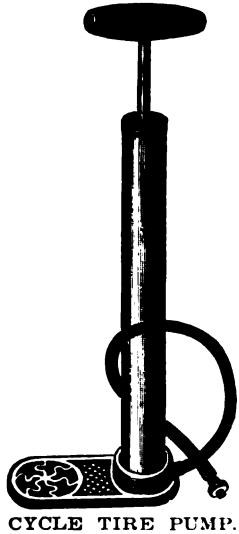
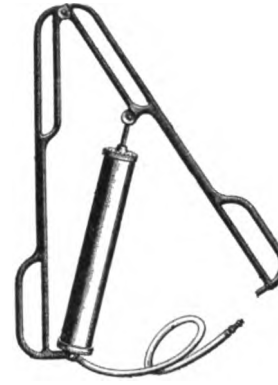
tires, compressed air is useful in the garage for gasoline tanks, pneumatic lifting jacks, and the like. The time may come when highly compressed air will be used for engine cooling, instead of flywheels and water jackets, as now used. Force feed instead of float feed carburetors might become the rule, if compressed air were easily available. All these uses would swell the demand for power pumps.

At present there are a large number of good portable devices for utilizing the power of the automobile engine for pumping air. Probably the most ingenious of these consists in tapping one of the engine cylinders over the compression space. A flexible tube from this tap leads to any one or all the tires at once. By shutting off the gasoline from this par-



CYCLE TIRE PUMP.



GLEASON-PETERS PORTABLE PUMP.

ticular cylinder and running the engine, the compression stroke in this tapped cylinder delivers any desired amount of air at very high pressure in a very little while. The cylinder thus becomes a perfect air pump of great capacity. This device has the additional merit of being very cheap, costing no more than the ordinary hand pump. Some other modifications of this principle do not shut off the gasoline, but let the cylinder run as usual and fill the tire or tank from the exhaust gases.

While the products of combustion may not be quite so good for tires as pure air, yet this modification is suitable for a single cylinder machine, while the device described above can only be used on a multiple cylinder motor. Either of these types can be used with a hub attachment which allows the tire to be filled without even stopping the car. They will

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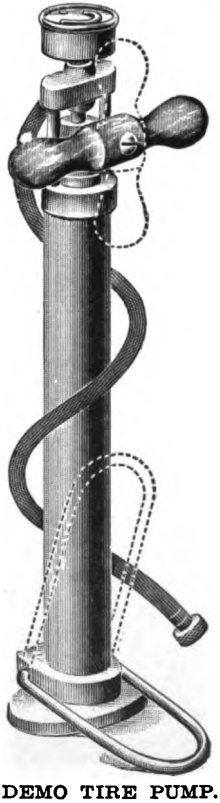
deliver air or exhaust gas to the tire faster than it will leak from an ordinary puncture, so that it is not necessary to make tire repairs on the road. This will probably be the most convincing argument of all, to the mind of the ordinary motorist. An automatic pressure regulator prevents the pressure rising above the desired limit; and by interposing a water jacketed tank, the air or exhaust may be delivered to the tires cool, which is important.

Most engine pumps are driven by a friction wheel held against the flywheel or the engine shaft. The simplicity of this principle appeals to many persons, and this type of pump is deservedly popular. Occasionally a pump is found which rests upon the ground and receives its power from the engine through a flexible shaft or torsion cable. One very simple device consists of a double barrelled pump with two handles, the barrels and handles all being in a line. By removing the starting handle, the piston crank engages the starting shaft and is thus driven. The whole device is no larger than a hand pump. Another pump driven in the



DEMO TIRE PUMP.

STAPLEY TIRE PUMP.

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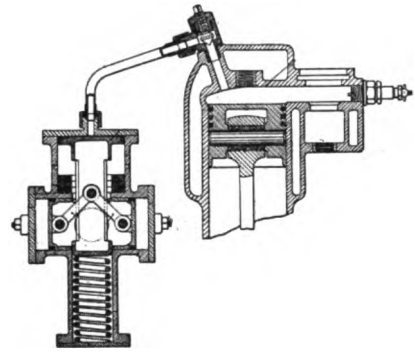
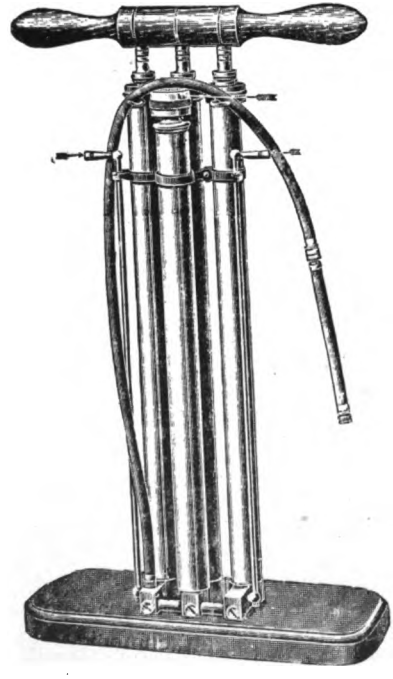


MICHELIN APPARATUS FOR INFLATING MOTOR TIRES.

same manner is attached directly to the starting handle, or rather forms part of the handle itself, like a crank within a crank. One end of the pump slips over the handle of the starting crank, while the piston connects with a short crank which engages the starting shaft. By holding the starting handle still, with the collar pin removed, the pump is rapidly driven by the engine through the starting shaft. The barrel of the pump is cooled by a calcium chloride jacket.



TRIPLE PUMP—ENGLISH.

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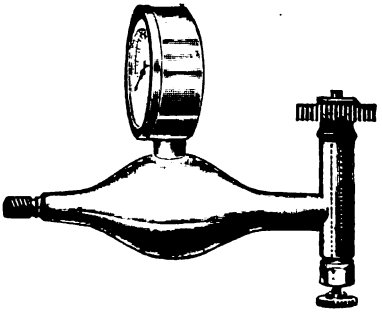
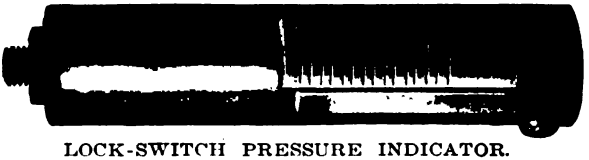
One of the neatest ideas is involved in a pump which is driven by the road wheel itself. The pump screws directly to the wheel spokes, with an eccentric fitting over the hub. The pump revolves with the wheel, the eccentric arm being held fast by a cord from the mudguard. The piston is thus driven by the turning wheel, and the tire inflated while running, the air being fed in faster than it leaks from the puncture. When filling a flat tire, the wheel must be jacked up.



WRAY PRESSURE REGISTER.

Pressure indicators or regulators are, of course, necessary on all power pumps, and they are coming to be used on all pumps. The ordinary pressure gage, which is attached to the pump and registers with every stroke, is apt to become strained and disordered much sooner than one which is protected from the pump stroke and only registers the actual pressure in the tire. Very few gages are really accurate, or remain so for long. Consequently several makers have abandoned the dial gage in favor of the pop valve or safety valve. The pressure on the outside of



LOCK-SWITCH PRESSURE INDICATOR.

the tire valve is generally higher than that within, or the air could not be made to enter. As a consequence, few tires are pumped as hard as the dial indicates; though, if the error is constant, it doesn't really matter. The safety or pop valve seems to be the best principle for power pumps, since the action is automatic, and the tire can not be inflated beyond the desired pressure. Some of these attachments are also touched upon in the chapter on tire valves.

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GAS INFLATION OF TIRES.

The question as to whether or not air is the best inflation for tires is most interesting. Certainly when engine exhaust is used much besides air enters the tire. Indeed, it contains much besides nitrogen, carbon monoxide and dioxide and steam, though these are all that are usually mentioned. As a matter of fact, there are also present lubricating oil and unburned gasoline vapor, neither of which is good for the tire. Then again the manufacture of liquified carbon dioxide is a regular business. Liquified carbonic acid gas in tanks is supplied in enormous quantities to soda fountains, and the manufacturers are glad to sell to automobilists. When it is remembered that a gallon of this liquid will fill two or three dozen big automobile tires, it is easy to see why CO_2 may be a competitor of air in the garage. Not only that, but liquified carbon dioxide is now put up in small packages especially for the use of motorists on the road. Carbon dioxide is only used, of course, because it is one of the easiest gases to liquify, and because it is comparatively inert. Chlorine and like gases would be easier to liquify, but they would almost certainly attack the compounding ingredients of the rubber.

This last brings us to another point; namely, the effect of different gases upon rubber. Almost from the very beginning of experimenting with rubber, it has been well known that many gases and vapors had a decided effect upon it, and that pure rubber would freely absorb and transmit all gases, with a facility depending upon the character of the gas, the temperature of the rubber, and on other circumstances.

Grosheintz found tubing of black rubber to transmit coal gas freely, while common gray rubber, which is heavily compounded, was only slightly permeable. Tests of various kinds of tubing showed that the purest rubber is the most permeable. Other persons have found that some gases are absorbed much more rapidly than others, though the reason why may not be known. Hydrogen passes through most easily, probably because it is the most impalpable of the gases; but then carbon dioxide, which is far heavier than air, passes through a rubber membrane about twenty times quicker than air, when the rubber is at about 70° F., but neither carbon dioxide nor hydrogen will pass through, when the rubber is at or below the freezing point of water. Air does not begin to escape through rubber until the temperature of the latter reaches 70° or 80°, and passes through more readily, as the rubber is heated. At high speeds, a rubber tire gets too hot to bear the hand, and at such temperatures air escapes to an appreciable extent through the inner tube. Carbon dioxide will escape many times as fast.

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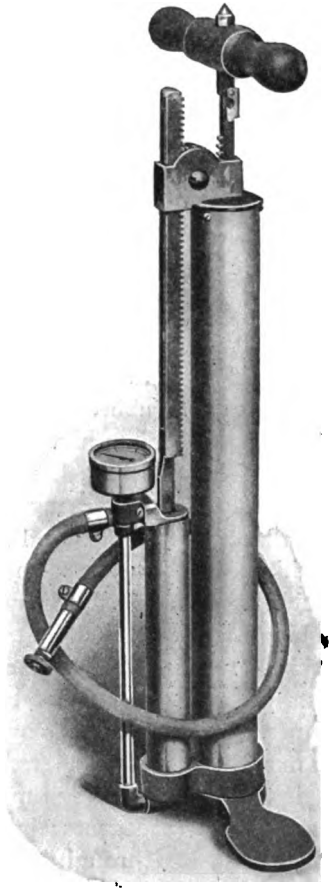
It must be remembered that air is made up of about 21 parts oxygen and 79 parts nitrogen, mechanically mixed. Of these two gases, the oxygen passes through far more quickly. After several refillings of the same tire, the contents will be found to be almost pure nitrogen. The oxygen, in passing through, also unites with the rubber, to some extent,



WRAY AUTOMOBOILE PUMP.

increasing the adhesive principle in the rubber at the expense of the nervous or elastic principle. In other words, the rubber becomes resinated or short, and the tire tube no longer swells freely, but bursts under a sudden strain. Nitrogen, on the other hand, is the most inert of gases, and will hardly pass through rubber at ordinary temperatures.

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It would seem best, therefore, if one could choose his filling, to have his tires blown up with nitrogen. This result might be approximated, however, by filling with air, if one were careful not to let his tires become wholly deflated. On the theory that it is only the oxygen which escapes, if one were careful to keep his tires well pumped, there would soon be nothing in them but nitrogen, since each increment of air is about four-fifths nitrogen, and the oxygen is constantly leaking out.

Thus the question whether tires should be inflated with gas or air is still an open one, if by gases you mean nitrogen or carbon dioxide. If the cylinder exhaust is to be used, it would be better to first run it through water, which is an easy task.

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CHAPTER XIV.

TIRE TOOLS AND ACCESSORIES.

WHEN motor cars were yet young, some of the automobile papers railed against carrying spare tires in conspicuous places about the machine, on the ground that they tended to convey to the general public an impression of the unreliability of tires. To be sure this fact should not be unnecessarily advertised, if one has at heart the good

THE L & M TIRE ADJUSTER.

RHODES TIRE REMOVER.

of the sport or industry, as he might consider it. Nevertheless, people who go motoring put their own interests first, and not only continue to carry spare tires, but hang them on wherever they are least in the way, without regard to what the public think. Nowadays, two or three tires hung on somewhere make part of the mental picture whenever an automobile is mentioned.

Comparatively few people realize that, unless properly cared for, a spare tire may suffer almost as much as one in use on a wheel. When a running tire becomes wetted, it stands a good chance to dry very soon, and corrosive substances will probably be discovered and removed; but

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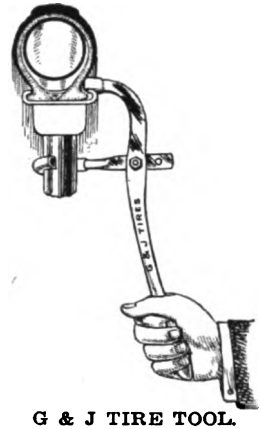
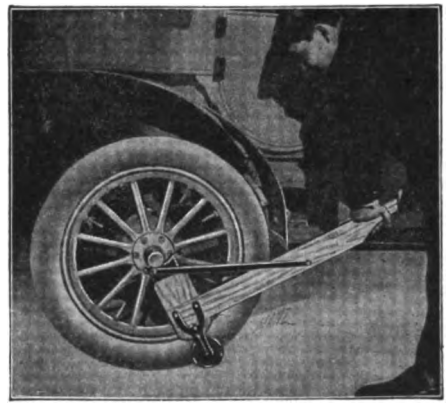


G & J TIRE TOOL.

if enemies creep into a spare tire case, the poor, dumb tire must suffer in helpless silence. Many persons have wondered why an uncovered spare tire does deteriorate so rapidly, and it really is hard to explain. Sunlight is the hardest thing of all on rubber, but the running tires are just as much exposed to the sun as the spare ones. Water does not hurt rubber



MURRAY AUTOMATIC JACK.

appreciably, but it does hurt canvas. The running tires never fit the rim so perfectly as to be waterproof, and they always get steamy after a hard run, showing that they are damp inside. When they become wetted, they have no chance to dry, while a spare tire will dry readily. At first sight one might think that this gave the advantage to the spare tire; but it is generally known among builders that wood which is alternately wetted

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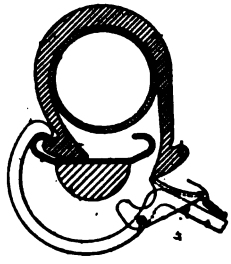
and dried will rot much sooner than wood which is kept wet. Cotton is not ordinarily supposed to follow this rule, however, though it is possible, cotton being a woody fiber. The spare tire is not working, either, and not exposed to road wear; so it really seems queer that a tire on the wheel should outlast one hung on a bracket, though there are plenty of people to confirm the fact.

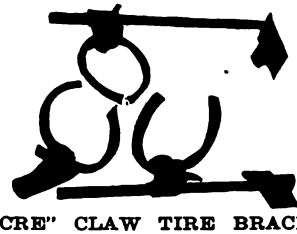
It has now become the rule to tie up spare tires in waterproof cases, which also protect them from light and air and flying oil. A case made of



MICHELIN APPARATUS FOR MOUNTING TIRES.

THE MORRILL TIRE JACK.

waterproof material is not necessarily a waterproof case, as many have found; and since a defective case may prove worse than none at all, one should be careful in his choice. The more progressive makers also furnish cases in several colors, to match the color of the car. A tire in its case is always a conspicuous object, so lovers of harmony in the color



"LACRE" CLAW TIRE BRACKET.

scheme insist on this point of color. Some automobile body builders have provided closets under the body, opening from the rear, in which spare tires and tubes might be carried; but there is so little room about a car, and so many things to be carried, that tourists used the closet for other things and hung their tires outside. Even when the tire cases were hung outside, they begrudged the empty space within the case, and now several makers arrange so that this circular space can be utilized. The Continental case provides for carrying several inner tubes within it; and

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others, as the Russell and the Brooks cases and Vuitton's *sac chauffeur,* contain within them a regular bandbox or metal drum, in which not only tubes and repair kit, but even small articles of clothing may be carried.

Tire case holders are important, of course, and several firms are now making a specialty of these. The Lacre claw tire bracket is perhaps

CONTINENTAL TIRE CASE.

the best known of these, though case holders are so simple in principle that almost any car builder can make them.

In what follows, the intention is not to make war upon the clincher tire, for it has been a good friend, and may yet serve many useful purposes in the world. The clincher seems to do good work, so long as it is on the rim. It is when one comes to take it off or put it on the rim, that

HOPEWELL TIRE CASE AS APPLIED TO FISK TIRE.

TEEL TIRE CASE.

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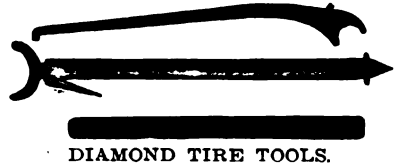
its special weaknesses crop out. The imposing array of tools necessary for the accomplishment of this serious purpose makes the best argument that the clincher's rivals could bring against it. The old argument for the Dunlop, showing two open hands as the only tools needed, never loomed up so mighty as it does when one contemplates the huge bulk in his tool box and the corresponding hole in his pocketbook caused by the paraphernalia required for the toilet of My Lady Clincher.

THE VUITTON TIRE CASE.

Tire tools were not made necessary until the coming of the motor tire, and especially the clincher. Bicycle tires needed no tools for detaching or

GILBERT'S INNER TUBE CASE.

applying, or for mending. For crescent rims they sometimes used a glue wheel for applying the cement, and vulcanizers very early came



DIAMOND TIRE TOOLS.

into use. The quick-repair and single tube tires required a cement squirt or repair tool, and slender jawed pincers were used for inserting single tube plugs. The pumps were the simplest things imaginable. The motor tire changed all this. First, there was needed a jackscrew to lift the wheel. Then a forked bar is needed to hold the wheel still, while the various pinchbars are used to prize up the bead. A special tool is needed to disengage the bead from the clincher seat, where it often gets stuck.

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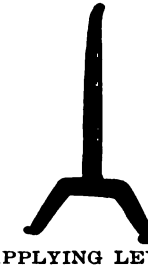
Special wrenches are made to unscrew the lugs, and thumbscrew clamps are put around the tire to hold back the bead when it is disengaged. A special lever, which fits the bead, lifts it up until the flat pinchbars can take hold. Many a man has become disgusted, at this stage of the game, and pried the thing off with a pickaxe or a crowbar. A crowbar is often found still more necessary in putting on a tire, though its use is apt to be attended with disastrous results. There are especial applying tools, generally made with two prongs. The different makers ring in various changes in their general shape. These small levers are often inadequate,

REMOVING LEVER.

WHEEL BRACE.



APPLYING LEVER.

however, when it comes to shoving the last 12 or 18 inches of bead over the rim. For this purpose a system of small jackscrews is made for lifting this last section of the bead. These jacks run from the hub to the rim, and several are needed to do the job properly, locking each while the other is being worked.

In addition to all these, we must count the anti skid devices, puncture shields, expensive power pumps, autobeds and other arrangements for taking the weight off the tires when standing in the barn, pneumatic jackscrews, spare lugs, and everything else that enterprising advertisers can coax the motorist into buying.

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CHAPTER XV.

THE CARE OF TIRES.

IF one listens to all the advice given by the tire makers and repair men on the care of pneumatic tires, the effect is something like reading the symptoms described in the patent medicine advertisements, or like trying to live up to the rules of the food cranks and physical torture societies. If the advice came to him before he had laid in a supply of pneumatics, he would probably follow the advice of the humorist on the subject of getting married and conclude to "don't." Strictly speaking, the combined advice of the tire makers on the care of tires comes to this, that the proper way to make tires last a long time is to take them off the wheels, dust them carefully with French chalk (talcum powder) and flowers of sulphur, wrap them in paper and then in tinfoil, and lay them away in a dark, cool, dry place. They must not be used on a car, because tires deteriorate in use. If they take up too much space in the bureau drawer or jewelry case, they might be traded off for a small white elephant, which will be much more useful and instructive.

The point on which all advisers insist most is proper inflation. Aside from this it used to be the custom among tire makers and dealers to say little or nothing relative to the care of tires. There were two reasons for this: one being, of course, that they wanted to increase the sale of tires; while the other motive was that instructions on care would necessarily reveal the weaknesses of pneumatics, and perhaps lead the buyer to believe that these weaknesses were peculiar to that make of tires, instead of being of general application. Pneumatic tires look so helpless that it is only those who are familiar with them who realize their strength; hence the policy at first adopted was doubtless the best in the end.

Nowadays, when pneumatics have ceased to be a novelty and their strength and weakness are generally known, the policy has changed to a campaign of education in regard to the care of tires. This is wise; because if a buyer has been thoroughly apprised of the frailties of his goods and told how best to avoid accidents, the responsibility is to that extent thrown upon the buyer, and he cannot put upon the seller the blame for mishaps. The consequence is that tire makers and sellers are practically relieved of tire guarantees, formerly so oppressive to them. The possibilities of the abuse of motor tires are so many that absolute

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guarantees, such as formerly applied to bicycle tires, are unreasonable and out of the question. The guarantee will hold if the driver can prove that the tires were not overloaded, that they were inflated to the prescribed pressure, given with every make and size of tire, and that he had used proper precautions in turning corners and regulating his speed to the character of the road. Moreover, the guarantee will not hold if he has used anti skids, and the mileage rather than the time limit is insisted upon. The consequence is that it is very hard to make out a case against the warrantors.

The care of a tire really begins before it is put on the wheel. Some claim that a tire fresh from the factory should be treated very gently for

TIRE AFTER ROUGH USAGE.

several days, until it has a chance to season and be broken in to the heavy work that it must do. This is simple superstition, since the reasons are not apparent. The maximum load which the tire is to carry should be known, and a tire of suitable size and strength selected. All tire makers have such tables of weights and measurements, though these differ so greatly that one's own judgment might almost as well be considered. Many persons, also, do not realize that the rear tires not only bear two-thirds of the total weight, but that they must also bear the tremendous driving strains and side thrust of skidding. In other words, the stress on the rear tires is three or four times as great as that on the front tires. The larger the rear tires the easier the car rides, and the smaller the front tires the easier it steers. Not only that, but the rear tires are much more likely to puncture or blow out, for which contingencies there should be

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an additional margin of strength; since every puncture permanently weakens the shoe.

Before mounting the tires, the rims should be carefully looked after. Rust seems to injure tires in some unaccountable way, the injury being far greater than one would naturally expect. Unless the rims are rust proof from galvanizing or nickeling, they should be well varnished or painted. In case of clincher rims, the flanges should be gone over with a file, to guard against sharp edges or projections. The tube and the inside of the casing should be thoroughly dusted with talc, since this lessens the danger of pinching, and it will sometimes prevent the valve being torn off by the creeping of the shoe, by allowing the shoe to slip over the tube, the talc acting as a lubricant. One trouble about using inside flaps is that they prevent this slipping of the tube within the shoe, and flaps are also inconvenient in some other respects. Still, they generally prevent the tube being pinched by the lugs, and also prevent its being caught under the toe or inside edge of the bead, when this tilts up, as sometimes happens when taking a corner too fast.

In fitting the shoe, some makers insist that it be put on in a certain way, in order that it can stand the driving strains better, the threads being stronger in this direction than in the reverse. If this be true, it is a serious fault in tire construction, because the strain when the brake is put on suddenly is as great as when the clutch is let in suddenly. Tires should be interchangeable on the same axle; that is, the fabric should be equally strong in both directions. As was shown above, however, it is doubtful economy to have the front and rear wheels interchangeable. The only advantage in this is that one spare tire will be enough on a trip; but one seldom needs a spare tire for his front wheels, and he may easily save the cost of one by using much smaller and lighter ones in front.

The most important point in the care of tires is inflation. If one is afraid to use the hand pump, it will pay him to get one of the many excellent power pumps on the market, which utilize the strength of the big roaring monster under the bonnet. The big 36 by 5 inch tires require about 100 pounds air pressure in order to get the most work out of them. There is a strong temptation to run them at 60 pounds, because they undoubtedly ride easier, and are about as fast. There is good reason in easing down the pressure a bit, because speed and resilience are what pneumatics are for, and there is no use in overdoing the pressure, which would cut down both these desirable qualities. Still, a well bloated tire will run a hundred times as long as a deflated one, so that one's pocketbook must be consulted when deciding on the pressure that he is going to use.

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By far the larger part of tire troubles come from running "soft." Rim cutting, side cracking, heating, creeping, and punctures are among these. The thicker the walls, the more a soft tire will suffer from the incessant bending, owing to the leverage brought upon threads and rubber, the former chafing and cutting, while the latter has its elasticity

PROPER INFLATION.
[This tire is inflated to the proper riding pressure. Every tire should stand up round like this under a full load.]

kneaded out of it and its virtue destroyed through heating. Most persons who run on soft tires do so through ignorance, not knowing what pressure they are carrying. There are plenty of pressure gages, but there is much dissatisfaction with these, especially with those which are attached to the pump. A tank may register 100 pounds pressure, and a hose from this attached to the tire valve will seldom deliver more than 80 pounds to the tire, owing to the friction in the valve. Even less accurate than

IMPROPER INFLATION.
[This tire shows the degree of inflation at which many tires are run. It is not pumped up enough and thus will not give the maximum of service.]

this is the pump gage, affected by every stroke of the pump, with the telltale vibrating so that readings cannot be taken. A gage that connects with the valve directly is fairly accurate, but rather inconvenient. If a pressure tank or a registering pump be used, one can safely figure that the gage shows 20 pounds more than the tire really holds.

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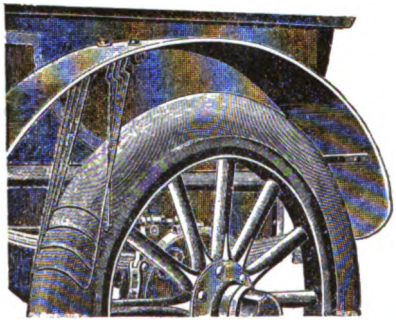
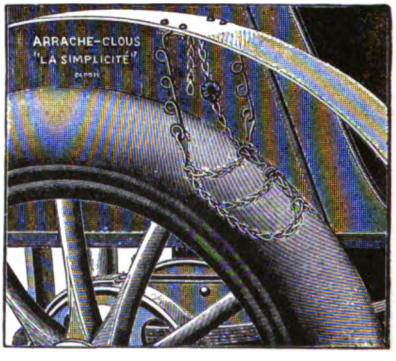
Good authorities claim that a tire which does not flatten perceptibly under its full standing load is inflated just about right for fast running. This, however, is accurate only within considerable limits, much depending upon the judgment of the driver in each particular case. Under inflation is more dangerous than over inflation, so that one need seldom fear that the heat from running will increase the pressure unduly. This heating is very injurious, but not in this way; because the more a tire is inflated, the less it will heat, other things being equal. The heat which it is possible to raise in a tire by overspeeding is probably greater than most people think, as the temperature sometimes rises above the boiling point of water. At such temperatures the layers of canvas are apt to become separated, through the softening of the rubber, so that the tire bursts.

When running on the road there is a great difference in the lasting



"TRIUMPH" NAIL FINDER—GERMAN.



"SIMPLICITY" NAIL FINDER—GERMAN.

powers of tires under different drivers. One driver may make a set run two or three times as long as another can. Those persons who only run cars in order to display their wealth probably do not care how long they last, and may even boast of the number that they have worn out. Those who run motors for the pleasure of it and can afford to do so, will not trouble themselves about their tires, and probably enjoy reckless driving. A low hung car with long wheel base is not much affected by a burst tire, especially one on the rear wheel. Consequently, such drivers will take chances on sharp turns and rough roads. Shock absorbers save much of the discomfort of rough going, and undoubtedly ease the strain on the tires. Skidding on corners can be largely prevented by the various attachments on the market, though skid treads greatly increase the strain on the side walls of a tire. Quick turns at racing speed will often wrench off a tire bodily, when fitted with anti skids.

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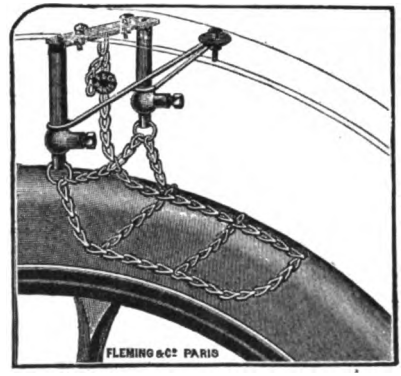
Any roughness in the road surface is greatly magnified in its effect by high speeds. The same road which seems smooth at moderate speeds will seem quite rough at very high speed. If there is a watershed or "thank-you-ma'am" to cross, the shock is much less, if it is taken on a slant. The wheels then get the shock one at a time, instead of two at once, so that the shock is cut in two. When crossing freshly broken stone, it is not absolutely necessary to slow down, but the clutch should be taken out, letting the car cross the strip by its own momentum. The tires are thus only exposed to the rolling motion, which seems to be less hurtful than the driving or traction motion. This can only be done, of course, for narrow strips of new metal; but this is the way in which it generally occurs.



"TIGER" NAIL FINDER—FRENCH.

Probably everybody knows by this time that acids, oils, and light are harmful to rubber, and that water is not. It is often necessary to run through water, but water does not find its way to the inside of the shoe very easily. It will work its way in in time, however, and if one is assured that enough has entered to wet the canvas, the tires should certainly be taken off to dry. This is very troublesome, however, and tires should be made waterproof within as well as without. Many self constituted advisers say that tires should have the dirt and mud wiped off them with a damp cloth after every run; but they don't explain how mud can possibly hurt a rubber tire. This may be a good idea, however, as it would reveal any cuts on the shoe which may have penetrated to the canvas. Such cuts will let water and gravel into the fabric and give much trouble. If small, they should be filled with thick rubber solution, and if large, should be vulcanized. It will pay to do so, if a repair shop is convenient. Sand or gravel will accumulate in such a cut until the rubber

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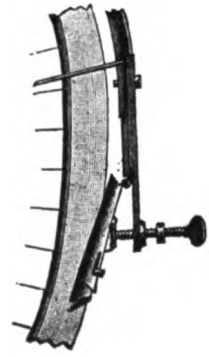
tread is cut loose from the canvas, forming a sand boil of ever increasing dimensions. The fabric will begin to rot, resulting in a blowout. Portable vulcanizers have been improved to such an extent that it is possible to vulcanize a cut fairly well without even having to jack up the wheel. The vulcanizer is strapped directly against the inflated tire, and requires only a half hour or so for the job. Still easier is the method of healing tire cuts with solution and vulcanizing fluids, many of which do fairly good work.



NAIL FINDER FOR CYCLE TIRES.

When not in use, it is best for the whole machine, as well as the tires, to be kept under shelter or at least in the shade. The sun has a bad and wholly unaccountable effect on rubber, though certain compounding ingredients lessen this effect. When standing in the barn for long periods, the tires should be kept inflated, though not necessarily at riding pressure. Many people consider it necessary to jack up the wheels, so that the weight is taken off the tires; but the damage from this source is probably exaggerated. Mineral oils, such as are used on roads to keep down dust, do not seem to attack rubber; but animal and vegetable oils are very bad, and tires left standing on the floor in puddles of lubricating oil may be wholly destroyed.

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CHAPTER XVI.

ANTI SLIPPING DEVICES AND TREADS.

THE inconveniences and possible danger of skidding were known to the early bicycle riders, and the makers sought to avoid such accidents by roughening the surface of the tires in various ways. It was very important, however, not to allow the roughening devices to interfere with the resilience of the tire, so that bicycle skid treads have been practically limited to ribs or some fretwork or other regular protuberances molded on the surface of the tire. Most of these are British, because the liability to side slip is greater there than almost anywhere else, owing to the peculiar sliminess of British road surfaces after a rain.

BAILEY'S "WON'T SLIP" TREAD.

It might not be too much to say that skid treads for bicycles are the rule in England and Germany, while they are rarities in the United States, because American roads seldom get greasy. In France, also, there is little need for skids on bicycles, though it was there that automobile skids first arose to importance.

The development of the motor cycle, with its high speed, drew attention much more strongly to the danger of skidding, and yet the necessity for resilience in the tires was hardly less than in the case of the bicycle. Consequently the makers were held down to rubber treads, though the corrugations in these were made deeper and more elaborate. Some of these motor cycle skids have a very businesslike appearance, especially the English makes, since the motor cycle industry centers in Great Britain.

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The boom in anti skids has come within the last few years, owing to the great speed developments in automobiling. All automobile skid treads serve two purposes, and many of them serve three or four. This is because of certain peculiarities in the automobile, which must be considered before the functions of the skid tread may be rightly understood.

On a hard, dry road, on glass, or even on ice, a rubber tire will probably hold better than one of any other material in the same shape. In almost all cases a smooth rubber surface gets a better foothold than a smooth iron surface, so that all rubber tires are to some extent anti skids. A round tire will generally skid more than one of any other shape; a pneumatic will skid more than a solid tire, and a "soft" pneumatic will

THE CALMON TIRE TREAD.

skid more than one that is blown up hard. Other things being equal, the more road contact there is, the more is the tendency to side slip, because the less will be the specific pressure upon the road at any point. On the other hand, the pull or traction of the drive wheels varies directly with the road contact, so that tires are specially designed with flat treads, to increase the road contact. Flat treads also have a certain non skidding effect when the sides come up square.

Thus it is seen that drive wheels need some provision against both forward and side slip. These two contingencies are apt to happen at once, so that, for the time being, the car is completely beyond control, it being impossible either to stop, start, or steer it. Such a condition is always awkward, and sometimes disastrous. It is the rear wheels which are most apt to skid, and raking or spinning the rear wheels or changing

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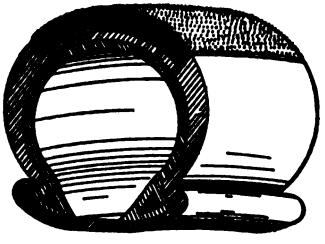
the direction of the fore wheels seems only to have the effect of making matters worse. Indeed, it has been the experience of most drivers that it is best, when skidding, to apply the brakes gently and turn the front wheels slightly in the direction of the skid. The philosophy of this is that a swiftly moving body tends to keep to a straight line. When the direction is suddenly changed, inertia tends to keep it in the original

SILVERTOWN TREAD.



ANTI SLIP TREAD—ENGLISH.

path. If the force of this inertia be represented by a line and the force of the impetus in the other direction be represented by another line, and a parallelogram be plotted from these two lines, the resultant of these two forces will tend to make the car skid along the line of the diagonal of the parallelogram. If the front wheels hold, as is usually the case, the rear wheels may be thrown around until the car actually heads the other way. Once the skidding is felt, a skilled driver will turn his front wheels

LEATHER RIVET STUDDED TREAD.

in the direction of skidding, and brake the rear wheels gently until the car stops, or the wheels have regained their foothold. By turning the front wheels the other way, the dangerous whirling motion is only increased.

Another thing which may be mentioned here, is that the demand for liveliness in automobile tires leads to their being made too light for

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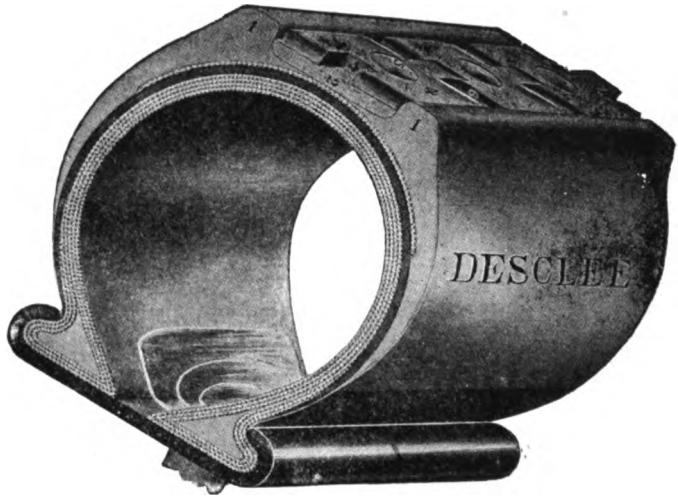

DESCLÉE TREAD—FRENCH.

OPTIMA TREAD—FRENCH.

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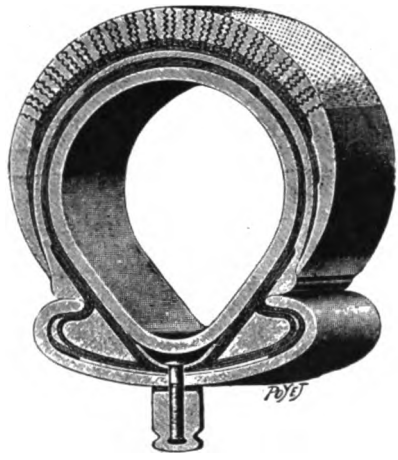

FALCONNET-PERODEAUD TREAD—FRENCH.

rough usage, resulting in punctures and blowouts. As a consequence, the demand for anti skids is generally accompanied by a demand for a covering that will strengthen the tire against inside pressure and also protect it against outside injury. Thus the result is that people buy flimsy tires with smooth, round treads, sacrificing everything to resilience, and then, frightened by the puncture bugbear, cover their tires with protectors designed to give traction, prevent skidding, punctures and blowouts, and to prolong the life of the tire. In such cases resilience is sacrificed, and the effect of the protector is often harmful to the tire.

LE MARQUIS TREAD—FRENCH.

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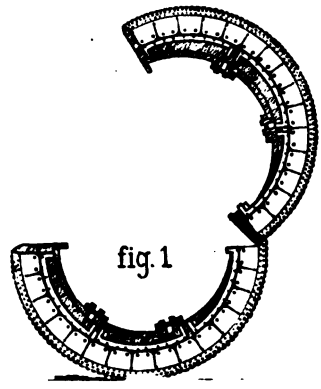
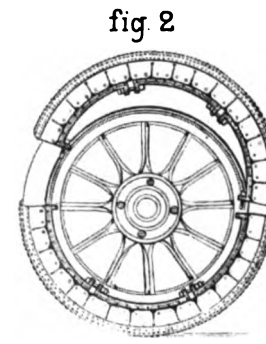
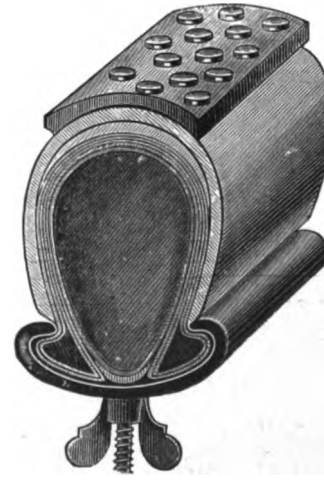
The development of automobile skids has been along lines quite different from the case of bicycles and motor cycles, because the makers have been allowed a freer hand. A soft pneumatic tire contributes greatly





DE FONIER TREAD—FRENCH.

to speed in each case; but where the good of the machinery is mostly concerned in the case of the motor car, in the case of the cycle the rigid frame makes the rider dependent upon the tires for whatever comfort he gets. In most cases the cyclist will take his chances on skidding, rather



CLERGET TREAD—FRENCH.

than give up even a little of the springiness of his tires. The automobilist, however, to whom skidding is not so much an inconvenience as a danger, is in a position to secure good footholds regardless of tire resilience, and

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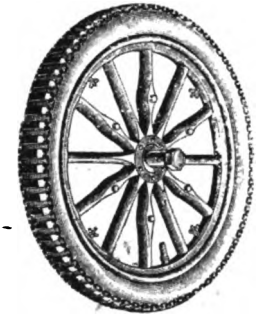
can protect himself against vibration by body springs and cushions. He can even run on solid tires, without hurting anything but the machinery. Consequently, if the skid feature is effective, he considers that alone.

Many scores and even hundreds of patents have been granted for devices designed to prevent tire slipping. One class comprises all tires



L'EMPEREUR TREAD—FRENCH.

BILLET-COUVERCHEL TREAD—FRENCH.

whose anti slipping feature results from indentations or protuberances molded upon the tire itself, including corrugated, flat and sharp treads, and twin tires. Another class takes in all skids made by vulcanizing studs or spikes into the rubber shoe. A third class would include all devices employing metal rivets, spikes, studs, or plates in combination with

GENARD TREAD—FRENCH.

DURAND TREAD—FRENCH.

leather, either detachable or baked upon the tire. A fourth classification would comprise all other devices, such as chains, wires, side hoods and other all-metal skids.

The first group was suggested by cycle skids and certain shapes of solid tires. Solid tires had been made in separate sections or had sections

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cut out of the tread in order to increase their resilience; but this was also found to prevent slipping, and the same idea has been applied to pneumatics. Racing tires are often made with transverse sections cut out of the rubber, or made with square treads, either smooth or corrugated. The Collier Tyre Co. are the chief exponents of the sharp tread, which very greatly lessens side slip and road suction, though it is less fitted for high speeding, through lack of road contact. Several firms still rely upon deep corrugations, though these are generally used in combination with the flat treads, so as to bring more of the ribs into play. The Diamond Rubber Co. seem to have been the first patrons of the flat tread, though not primarily as an anti skid. In 1903 Falconnet-Perodeaud brought out a flat tread in which the anti skid feature was made prominent. On solid tires there is no limit to the depth of the corrugations, and from the standpoint of our present study, twin and triple tires may be regarded as extremes of corrugation. Twin or block tires both lessen skidding very considerably.

The second group of treads has come much to the front more recently, owing both to extensive advertising by a large tire concern in Europe and to the popular belief that leather covers or protectors really injure the tire. Many repair men hold to this belief, which has been heralded over the world by the Michelins. The theory is that leather covers greatly

CROMWELL TIRE PROTECTOR.

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accentuate the effect of heating, quickly destroying both the canvas and the rubber. In high and prolonged speeding this would probably be the case, though at moderate speeds a leather cover undoubtedly prolongs the life and increases the mileage of a tire. All tires develop heat, when going at high speed, and a leather covering certainly retains the heat and "sweat." Though the resulting heat could hardly be enough to overvulcanize the rubber, it is barely possible that the heat and moisture may set up some destructive chemical reaction with one of the various compounding ingredients in the rubber. It is held by some authorities that sulphuric acid, for instance, may be produced in rubber by the simple action of moist air upon the free sulphur present. If this be true, the action would be much hastened by the scalding heat developed in a covered tire running at high speeds. As for the canvas, it would be

CHAMEROY VESINET TREAD—FRENCH.

hurt by the sweat, to some extent, though that is not enough to explain its rapid decomposition. Early tire makers, who used linen fabric, complained of injury to the linen during vulcanization, and cotton was found to be more resistant; but any acids that might be produced in the tire by high speeds would readily injure cotton canvas. The chafing of the shoe by the leather protector could hardly be enough to hurt anything.

The idea of vulcanizing studs or spikes into the rubber tread is not very old, though four or five years ago some of the makers had tried screwing or riveting these through the shoe. These were found to chafe the tube, however, and it became necessary to embody them in the tire before curing. Even then there was some wearing action upon the surrounding rubber, since the studs were not in true contact with it. In the latest types, however, the studs are first copper plated or otherwise treated, so that through the effect of the sulphur of vulcanization the

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TIRE PROTECTOR—AMERICAN.

rubber forms a true union with the studs. Such a contact cannot be broken, and the studs or spikes wear down under road friction without showing any tendency to be driven through the shoe. It is also claimed that such a skid feature, instead of shutting in the heat, as in the case of leather treads, actually helps to carry it away through the studs, much as the metal offsets on an air cooled cylinder increase the radiating surface and conduct the heat from the cylinder. In this way, by taking up much of the wear and by carrying off the heat, baked-in studs are said to prolong the life of tires very considerably, without appreciably affecting resilience. Road suction may also be slightly relieved, and in some cases, as in the Falconnet-Perodeaud tire, the crimps and loops

AHLBON TREAD—GERMAN.

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in the wires prevent cutting and puncturing, at least to a considerable extent. As a rule such skid treads are not puncture proof to any great degree, and no such claim is made for them. As a purely non slipping device, however, many experts feel that they have solved the problem.

As was brought out earlier in this chapter, a motor tire is exposed to more accidents than skidding. Being rather expensive, the road wear and the possibilities of blowouts, cuts, punctures, sidecracks, bead tearing, sand boils, and other contingencies must be reckoned with, as well as tire slipping. Many skid treads also serve several or all of these purposes, and for that reason they appeal powerfully to many people. Then, too, skidding is not a constant danger, and there is a great demand for detachable treads, which can be used or not, as occasion requires.

Thus it happens that our third classification, which comprises all combinations of leather and metal, is the richest field of all, and probably best represents the popular idea of a skid tread. There is an immense number of such treads on the market, and with the exception of the one disadvantage pointed out—namely, that they tend toward overheating the tire—this class may be said to have fulfilled all the requirements of anti slipping, besides the general protective and strengthening functions. The use of leather in treads has taken a strong hold upon the popular mind, and the development has been, as it were, a function of two variables. It being generally agreed that an ordinary tire will not last as long when completely covered by leather as when running bare, the development has been in two different directions. In one case, the leather has been narrowed until it merely covers the tread of the tire, or in the case of the detachable, various ventilating devices are resorted to, so that the heat may get out easily through the walls. In the other case, resulting from the application of a little horse sense, the tire makers decided to leave the rubber covering off of the tire, substituting for it a complete leather cover, which is cemented directly to the canvas.

Other makers went a step further and put in another layer of leather instead of the traditional flimsy cotton canvas. This last step is deplored by some, on the ground that leather will not allow the strain to be properly distributed, making the all-leather tire weaker, as a whole, than a cotton one. These persons rely upon the several layers of rubberized or frictioned canvas for strength, and upon the leather cover for protection and to carry the studs or other slipless feature. The objection occasionally heard, that leather covers are not resilient, is without foundation. Leather covered footballs and punching bags are resilient enough. Another objection, once true, that wetted leather becomes stiff on drying, no longer holds, either. By soaking in metallic salts, as in chrome leather,

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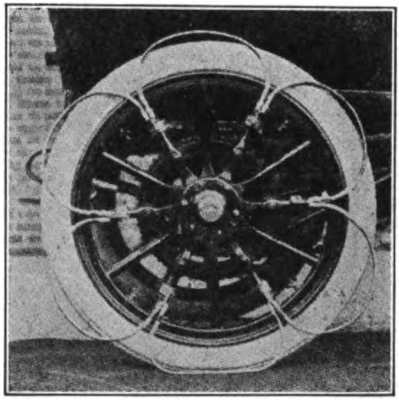
or by forcing or frictioning rubber into the pores, as in the Australian rubberized leather, the material is made more or less resistant to water. The almost incredible toughness of leather is known to all, and its very high wearing power may be reinforced to any required extent by metal studs or plates.

Thus, upon such a study of leather as a function in skid making, many men have based their prophecy that leather is the natural material from which to make tire shoes, as well as ordinary foot shoes, and that all tires will ultimately be made of leather armed with hobnails. The rubber which at present lies between the canvas and the leather cover is expensive, does no good, and is simply in the way, destined to be destroyed by the heat generated by the friction of its own particles in bending.



EYRE ANTI SKID—ENGLISH.

Many leather and steel skids, as now made, simply cover the wearing portion of the rubber shoe, being cemented tightly upon it, leaving the tire walls bare. Others are riveted upon the leather cover in such wise that the edges jut out free over the tire, giving a flat tread. Even without studs, such a rolling strip or sole forms a valuable skid feature, especially in mud, snow or loose gravel. The studs are especially designed for slippery flat surfaces. It may sometimes happen, however, that sharp gravel or little flints will get caught under the projecting edges, where, under the regular compression of the tire, at that point, they will cut the shoe out badly. By bevelling the under edge of the tread sole, as many makers now do, this rather remote contingency is prevented. When such a flat sole is used on a tire, it is customary to run the leather cover well down over the walls, and generally over the bead as well. Some critics claim, however, that it is better not to have the leather run over

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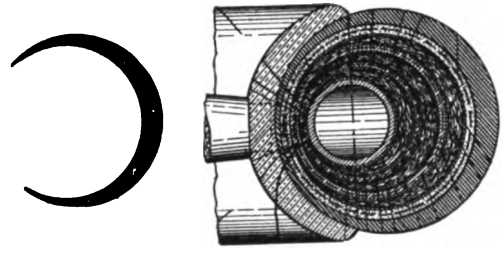
CORK FILLED PUNCTURE PROOF TIRE.

the bead; because in severe side rolls the walls cannot stretch, with the result that the sole will be wrenched off or that the bead will be torn. As a matter of fact, this seldom or never happens.



FABRIC FILLED PUNCTURE PROOF TIRE.

Detachable skids have had a much greater vogue in Europe than in the States. The reason probably is that in Europe the skidding season can be calculated with some certainty, and during the rest of the year

MITCHELL PUNCTURE PROOF TIRE.

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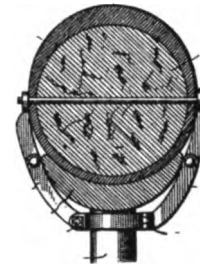
people prefer to run on bare tires. Some of these removable treads are neatly made, though in England and Germany, where skidding is frequent, appearance counts for much less than in America and France, where skidding is less usual. Detachables are always more or less cumbersome, and they sacrifice a good deal of resilience, but they do their duty well, and have certain advantages. There is undoubtedly some tendency to chafe and creep, but the injury from this source is largely overdrawn. To be sure most of them depend upon inflation to hold them in place, but then running on loose tires is bad practice for several reasons. Most detachables are also held on by straps, cables, hooks under the rim, or some other fastening, but there are several which depend wholly upon inflation to keep their place. Some of the latter have been known to come off while running. Since their hold upon the tire depends upon circumferential tension, they necessarily stretch more or less—about one-

ELDER PUNCTURE PROOF TIRE.



FITZSIMMONS PUNCTURE PROOF TIRE.

half inch to 100 miles run, according to some authorities. For steady running, detachables are hardly as cheap as the baked on type, and probably cost about as much in the end as running on bare tires, leaving out the puncture question. Thus it hardly pays to use leather covers on rubber tires, except for the anti skid feature. However, the defects pointed out are being remedied, to some extent, all the time. Tire makers are giving more attention to the theory of tire service, and have learned a good deal. Thus it was long believed that the heat which destroyed tires arose from road friction, and the Pullman band, an English tread, was advertised as having a layer of asbestos under it to keep the heat from getting inside. Nowadays everybody is trying to get the heat out.

The fourth classification of treads takes in chain and bar grips, wire loops, toothed rim plates, and other all-metal devices, as well as separate skid straps fastened on at intervals. This group includes both fast and detachable types, the detachables being more generally popular. The

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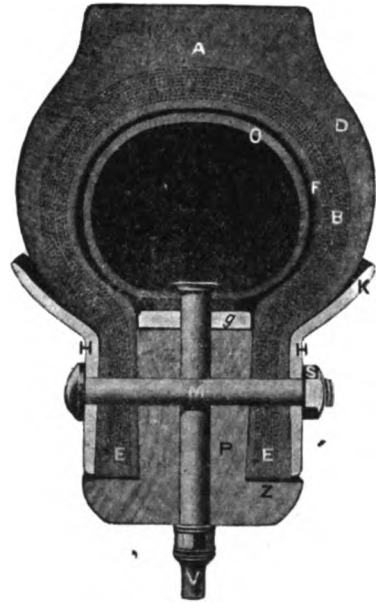
several chain grips are the best known in this class, being easily put on or taken off, doing their single duty to perfection, and taking up little room in the tool box. If used straight along, they are apt to cut the tire; but being so easy to handle, they are only expected to be used when they will probably be needed. Most of the chain and bar grips are made with the cross chains loose, to avoid continuous pressure in the same place, and contrary to all other kinds of tread, the whole device is expected to creep gradually around the tire in running. Thus the wear is evenly distributed. The separate skid straps, fastened at intervals around



PIGEON PUNCTURE PROOF TIRE.

tire and rim, or hooking under the clinches, do very effective service as creepers, and are very convenient. Some of them can be put on without deflating the tires, a point which appeals to many. They are also serviceable in case of bad blowouts or cuts in the shoe, and indeed this is what they were originally intended for, though they were found to make good, cheap and convenient skids.

A number of all-metal tread armors have been marketed, though some of these are not built on scientific principles. Some of them are very effective as skids and protectors, but at the expense of too much resilience. Those of the wire loop or drag chain devices are very ingenious, and do their work well, doing it also only when needed, being at

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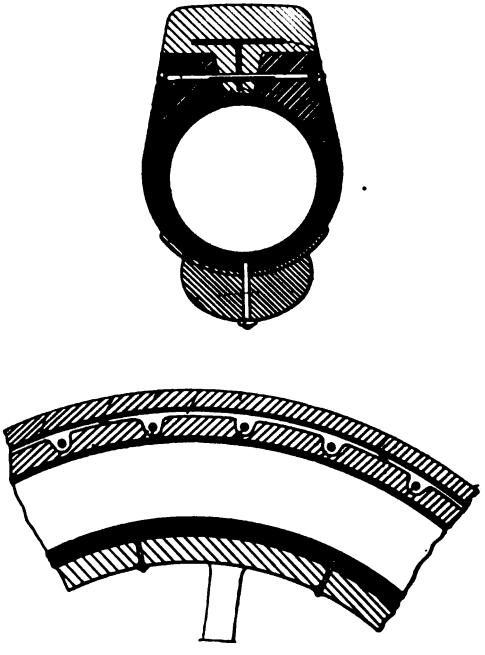
other times out of the way and not liable to hurt the tire. This is perhaps the most attractive idea of all, and when it is perfected, these skids will probably have a great run.

Many anti skids are also "puncture proof," which leads up to a consideration of that class of tires.

PUNCTURE PROOF TIRES.

It is easily possible to make a puncture proof pneumatic tire, but this end has hitherto been gained at the expense of some other valuable feature of the tire. Solid and cushion tires are puncture proof, or rather a puncture does not affect them; but these types were known before pneumatics came, and they were abandoned in favor of pneumatics where speed or easy riding was required. For the sake of speed and resilience people will continue to use pneumatics, taking their chances with a puncture. After all, with proper precautions, punctures are comparatively rare, and it is every day becoming easier to repair tires, thanks to detachable rims, portable vulcanizers, and improved repair kits. The ideal tire, from the standpoint of speed and resilience, is the very one whose walls are thinnest and most pliable; or, in other words, the one which is most liable



MAY PUNCTURE PROOF TIRE.

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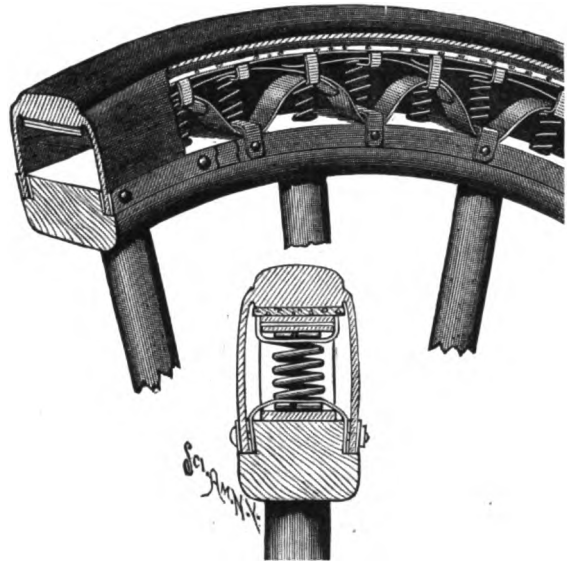
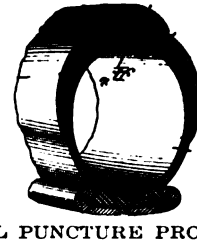


RAMSEY SPRING TIRE.

to puncture. For complete immunity against puncture, men will undoubtedly give up some tire resilience, but not very much.

Tire makers look upon "punctureproofness" as a question of degree. This or that tire is 50 or 90 per cent. puncture proof, according to their claims. This attitude is perfectly scientific, too. Whereas pins and tacks would readily prick a bicycle tire, a motor tire is proof against these, as



DEVOLL PUNCTURE PROOF TIRE.

well as hedge thorns and barbed wire, merely on account of the thickness of the rubber tread. A leather tread makes a motor tire proof against tin cans, bottle glass, and sharp flints, the cause of most accidents to rubber tread pneumatics. On the other hand, should a heavy car run over a substantial wire nail sticking through a plank, it would probably get a puncture, even if the tire were covered with sheet iron. Suppose a tire

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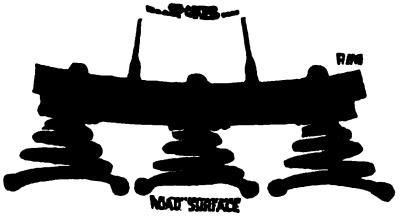
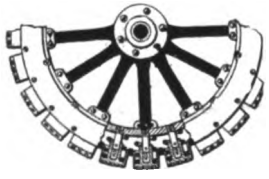
covered with a half inch of rubber should pick up a loose nail squarely: with every turn of the wheel it would be driven in deeper, and it is bound to penetrate anything short of a stout metal plate. There are several puncture proof tires which contain metal plates, chain armor, and the like, and these have their patrons; but even when these do not cut down the resilience very much, the internal armor often proves a source of trouble. Chain mail, vulcanized into the tread, or inserted between tube and shoe, makes one of the best puncture shields, and it is very likely that



"SYRINX" SPRING TIRE.

the solution of the problem lies in that direction; but while these shields are marketed, they have not come into general favor. Some makers surround their tires with overlapping steel plates, or even with rigid wood or metal treads; but these greatly reduce the pneumatic effect, and the tires, while being more expensive, are shorter lived than the naked tire.

An ingenious puncture preventive principle, lately revived, consists in filling the tread of the tire with hairpinlike steel bristles, crimped to get a better hold upon the rubber. This method is very efficient in pre-



BUNKER SPRING RIM.

AMERICAN SPRING RIM.

venting cuts from glass or other broad edged objects, especially those which attempt to enter the tire in a diagonal direction. However, these radial hairpins would seem to offer little or no resistance to the entry of a nail; though it may be repeated that few types of puncture proof tires will ward off the direct thrust of a nail.

Many types of puncture proofs are made on the principle of simple thickening of the tread, sometimes inserting a pad of felt, or wadded cotton, which does resist puncture very considerably. The insertion may

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be a layer of cork or any other substance, but the principle remains the same, and these inserted layers bring protection only at the cost of resilience. Another type of puncture proof contains a layer of rubber softened by some process and put in under compression, so that holes through the tire are automatically closed. This is the self sealing class of tires, quite popular in England. Some might not call these puncture proof, but the general effect is the same.

Though many puncture proof tires are marketed, it has become customary to gain this and other ends at the same time by combining several

GERMAN SPRING RIM.

features in a special tread, made to fit any tire. These treads, usually of leather, offer great resistance to punctures, while generally carrying hobnails to prevent skidding, and at the same time relieving the tire from road wear. This is the form in which most "punctureproofness" is gained, nowadays, and some of these treads are so effective as to practically solve the puncture problem. They all cut down resilience to some extent; but the loss in speed from this source is about made up by the better traction which they give, and at the same time they are serving other good purposes.

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CHAPTER XVII.

TIRE TESTS AND TESTING DEVICES.

THE rubber tire business will succeed, as it has succeeded, only in so far as it attracts the attention of the practical man. The enthusiasts and sport lovers may be necessary to float a scheme through its early beginnings; but once the novelty wears off, these patrons desert the enterprise, and it will sink unless it has shown some utility.

To the matter-of-fact man, the scientific, practical testing of rubber tires is a most important phase of the industry. He is interested, perhaps, in their history and manufacture, but it is results—their actual behavior under running conditions—that mostly concern him. He is vitally and financially interested only in the way the thing actually works.

There are two methods of testing tires: one in the shop and the other on the road. The practical man is more interested in the latter method, it meaning more to him, because that is where he is to use them. Nevertheless, it may be fairly doubted whether the road test is really more instructive than the factory test, because of the lack of any actual basis of comparison. On the road much depends upon the driver, the weather, the varying conditions of the track, and countless other things, which upset the calculations and indirectly influence the results until they have little value for us. The behavior of tires is positive and relative. Both are important, but it is in the shop only that the latter can be determined with any degree of accuracy. Consequently, while not underrating the value of road tests, it is worth while to call the attention of actual and probable tire users to some of the testing machines employed in the factories where tires are made.

It would be hard to say which of the great tire centers has done the most and best work in testing. The French are probably oftenest heard of in this connection, because of the publicity which they succeed in giving to their efforts. The Germans are very strong on the theory of tire construction, and are among the quickest to appreciate the value of deliberate or accidental tests made elsewhere. Still, a test is a test, wherever it is scientifically observed and recorded. The factory tests are coming to imitate road conditions, as far as possible, at the same time keeping a basis of comparison. Consequently they are becoming of increasing interest, even to the practical man, who is more and more

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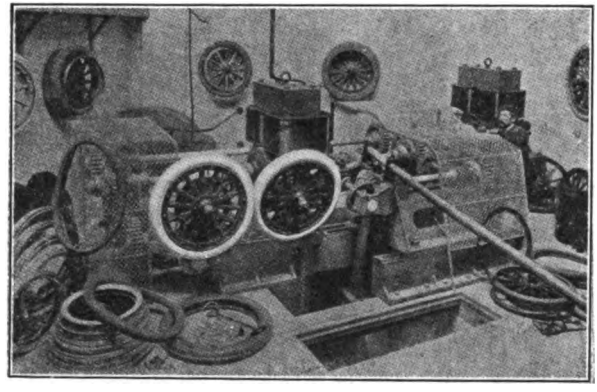
inclined to favor those tires whose makers attach most importance to this point.

In the best modern tire factory everything is tested before it enters into the makeup of the tire. Rubber is notoriously obstinate in doing what the pompous chemical formulas demand of it, so that experience and personal judgment are almost wholly relied upon in its manufacture. For inner tubes elasticity is the main thing, and this is shown in the stretching test, where rubber ought to stretch four times its length. For frictioning the canvas, adhesiveness is the point, while toughness is required in the tread, to resist cutting. For the canvas, strength and flexibility are the essentials, though it should also resist decay and the action of the vulcanizing and compounding ingredients; the threads must not chafe, where they overlie each other, nor must they contain air in their pores



PALMER TIRE TESTING DEVICE.

to keep out the friction rubber. The fabric plies must be tested for their adhesiveness to each other, and the rubber tread must stick tight to the canvas; for it is in these matters that many tires fail, long before they should be legitimately worn out. The relative and actual thickness of the rubber on the walls and tread is the result of careful tests, as is the number and strength of the breaker strips, the size, shape and strength of the bead or other means of holding.

If it be a solid tire, the means of anchoring is the main thing, because tests show that nearly all solids break from their fastenings long before they are really worn out. Tests are also necessary to show the proper size, shape, and height of the solid in order to get the best results in endurance, resilience, and traction. It must be tested for creeping and heating, skidding, and so on. Cushion tires must be tested against side cracking, single

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tubes against "porosity," spring tires against metallic wear, and leather tires against water hardening.

In the manufacture of pneumatic tires it was soon found that automobile tires are subjected to strains wholly foreign to bicycle tires. Among these is the terrific side roll met by the auto tire in skidding and in turning corners at high speed. The bicycle leans, when rounding a bend, so that the strain on the tire is always vertical. This is the hardest treatment that the auto tire is ever called upon to bear, the strain affecting every part of it. It is now seldom that the bead is torn off, but it will search out any weakness in the fabric, and perhaps tear the rubber tread from the canvas or separate the plies. Driving strain is also hard upon the tire, especially in sudden stops and starts. It is for this reason that the canvas layers are cut on the bias, so that the threads may lie in the direction of this tangential strain.

One of the earliest testing machines for tires consisted of a pulley, to represent a road, with cross pieces at intervals to represent obstacles encountered. Upon this ran a tire mounted upon a wheel, the wheel being weighted up to average or maximum load. When the pulley was turned, it gave the effect of a tire running over a rough road. By speeding the pulley a treatment could be given the tire which was far more severe than a rider could give it. This was merely a general strength test; and though it was sufficient for bicycle tires and wheels, it has been found of little use for automobiles, since it gives no clue to resilience, wearing qualities, "punctureproofness," resistance to cutting, side roll, driving strain, rubber-to-fabric adhesion, or any other of the features so important in an automobile tire. This primitive machine has accordingly been succeeded by various devices, each of which tests a tire for only one or two qualities.

The principles of some of these testers were utilized several years ago, however, and good results obtained with very simple apparatus. Thus Mr. Charles E. Duryea made an excellent resiliometer by the simple expedient of fastening one end of a mock axle to a wall, with the wheel and mounted tire on the other end, which end also bore a pencil. The wheel was lifted and dropped; and when a vertical plane bearing a paper was slid past the end, the pencil recorded the number and height of the rebounds. He found that the resilience of tires varied from 90 to 55 per cent., which is more than one would expect. His tests covered many kinds of tires, with and without protective covers and armor treads. It was demonstrated that the liveliest tires were those with cross thread fabric, though this construction will not stand the driving strain in auto tires. Mr. Duryea also originated a very neat method showing how

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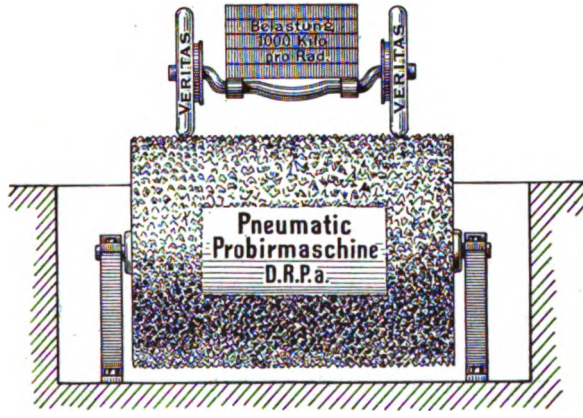
le pneu boit l'obstacle (the tire drinks the pebble). A marble was put upon the floor with a piece of lead wire laid upon it. When loaded tires were run over the marble, the extent to which the wire was bent around it demonstrated the tire's ability to swallow the obstacle. Resiliometer tests were also made by allowing the tire to bounce from an obstacle, such as an inch rod, instead of from the smooth floor. The two surfaces gave different results in resilience.

The resiliometer used in recent British tire trials was something like a pile driver, in which a ram of known weight falls a known distance upon a tire of known dimensions and air pressure. One pointer registers the greatest compression from the blow, while another indicates the extent of the rebound.



BERLIN-FRANKFURTER TIRE TESTING DEVICE.

The Palmer Tyre Co. have probably carried tire testing as far as any rubber manufacturers in the world. Their resiliometer consists of a frame in which a mounted tire falls a known height upon an anvil. Their most interesting machine is one bearing two movable axles, each axle driven by a separate motor. When wheels are mounted upon these axles, they can be brought together at any pressure by a heavy pendulum, the flattening of tires being a good resilience test. When one of the motors only is running, the effect is that of a smooth, level road. When the pendulum is oscillated, the effect is that of a wavy road. When the tires are run together at an angle, the effect is that of turning a sharp and continual curve. Oscillation of the weight makes this a series of sharp and gentle curves in the road. By disconnecting one motor and putting the brake on that wheel, the effect is that of climbing a steep hill. When the weight is oscillated, the results are similar to a series of sudden stops

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and starts of an automobile, so that the tire's ability to stand driving strains is severely tested. Each motor can be used as a dynamo, when reversed, so that by using one as a dynamo and the other as a motor, the tractive efficiency of the tire is accurately tested, at all pressures of load and air, the results being shown by a glance at the two switchboards, one of which indicates the amount of power used, while the other indicates that produced. This machine is one of remarkable interest, though the conditions are not exactly those of the road. The makers of the "Veritas" tire, in Germany, in an effort to reproduce road conditions more nearly, made use of a heavy belt for a road, this belt traveling under a loaded automobile. By cementing a fine assortment of flints upon the belt, the effect given was that of an extremely severe road, which thoroughly tested the wearing qualities of the Veritas tires.

It has long been known that the best of valves will leak a little, and that this leaking varies even in the same tire at different times. Some of the German experimenters have accurately measured this leakage by connecting the valve with a U-tube made by coupling several lengths of gas pipe and filling with water until the air pressure is balanced. The rise and fall of the water level, as seen in the glass tube fitted in, makes an exceedingly delicate gage.

That the danger of punctures is greatly exaggerated, in the public mind, was shown by some tests made in London. A stretch of roadway was thickly strewn with broken bottles, bent nails, spikes, chisels, and other sharp objects, and over this road a racer and a touring car were driven at 50 miles an hour. The racer was soon punctured, but the touring car ran over the road a dozen times before a puncture occurred, and even then the flat tire seemed to make no difference in the running. In some skidding tests held in England, a puncture was found to have a very great effect upon the running. When a front tire was voluntarily punctured at high speed by sticking a knife in it, the effect upon the steering was to throw the car completely around. The tests showed the importance of the size of the hole, or the quickness with which the air escaped, and also showed that rear tire punctures are never dangerous. A tire was also loosened at one side and allowed to come off at high speed, but the running of the car was not affected.

The British tire trials held in the winter 1905-06 were a failure, because the excessive fees excluded all but one firm, the Collier company. The required weight of the cars was also excessive, running from 3000 to nearly 5000 pounds, and the estimated tire cost, at the end of the 4000 miles, ranged from 5 to 13 cents per car mile, for the three cars entered. The test proved little.

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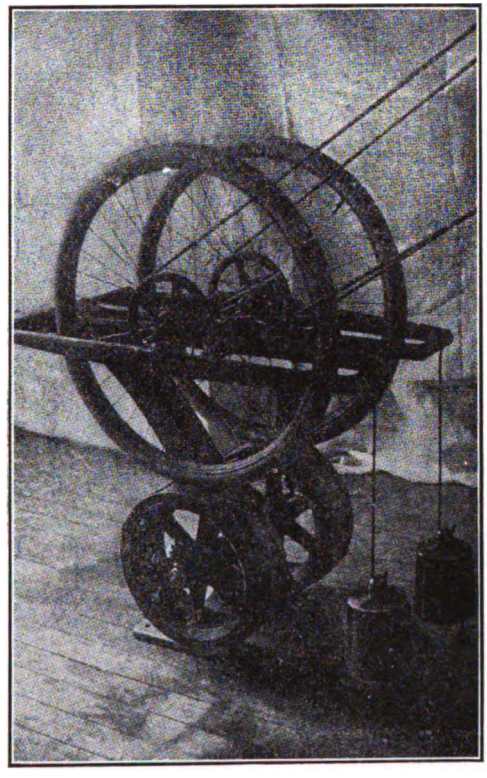
Many interesting traction tests have been made in England with various tires with different loads and air pressure. Most of these tests have been practically fruitless, however, even with conditions virtually identical. Some of the results are conflicting, one series of experiments being favorable to narrow tires, while some others favor wide ones. In many cases, laboratory tests, dynamometer road tests, and road tests



HARTFORD TIRE TESTING DEVICE.

on the basis of power or fuel consumption, all give results so unlike as to prove nothing. Dynamometer tests show results in favor of solid tires over pneumatics, under certain conditions of load, road and speed, though this is contrary to universal experience. Several French dynamometer tests have favored solids, under certain conditions, purely from the standpoint of tractive effort. Thus, a French test on good, dry macadam at 13 miles an hour, showed that the tractive resistance was for solids, 33 to 40 pounds a ton; for 3½ inch pneumatics, fully inflated,

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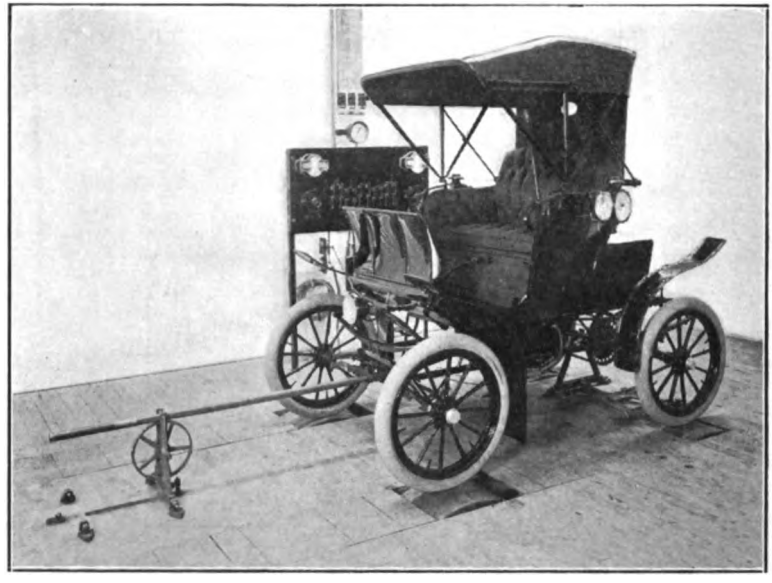
44 to 53 pounds; same, half pressure, 53 to 61 pounds; for 4 8-10 inch pneumatics, 64 to 70 pounds per ton. Michelin's tests, at the same speed, dry road, gave the traction advantage to the pneumatic in the ratio of 25 to 30; on wet roads, the pneumatic was to the solid as 32 to 36; on quite muddy roads, the pneumatic was 35 against 43 for the solid. Thus it is seen that the two tests contradict.

The truth of the matter is perhaps best brought out by Dr. Alberto Pirelli, in a paper read recently at Milan, on the general question of rubber tires. He gave the results of many careful experiments at his



BAKER TIRE TESTING DEVICE.

factory, concluding that tests for any one quality in a tire are worthless, when standing alone. A tire which is exceptionally resilient may wear rapidly on the tread and puncture easily, though it heats little; while a tread especially made to resist wear and punctures may heat so rapidly as to soon destroy it. His tests showed that tires may frequently be heated up to or even above the boiling point of water, though not to the vulcanizing temperature. Four inch tires at 45 pounds air pressure rose to 70 pounds pressure, at high speed under load; while the same tire under the same conditions, but with an initial pressure of 90 pounds, gained only 15 pounds. Other things being equal, the larger the tire, the higher the pressure, and the purer the rubber, the less is the trouble

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from heating; but then these are things that any motorman knows without factory tests.

A special line of tests that were instituted to determine what types of tire were best for electrically operated automobiles brought out much information of value. For example, on an absolutely smooth road, a solid tire uses up from 20 to 30 per cent. less power than does a standard pneumatic, and a steel tire less than that. Again, a pure gum solid tire will consume 10 per cent. more current than a tire containing only 20 per cent. of rubber.

The best tests that have been made have been where a certain type of vehicle has been selected, equipped with different kinds of tires, and run over the same roads at a given rate of speed, and the difference in current consumed is carefully tabulated. Taking 125 as the highest efficiency possible—

A single tube thread tire rated at	121
A two-ply tire	99
A four-ply of the same make	93
Another type of thread tire	89.5
A cord tire	89
A special fabric	88
Still another cord tire	79
Another thread	75
One type of standard clincher	55
Another type	53.7
And still another	49

It will thus be seen that the type of tire has great effect upon the economy of running an electric. The tires mentioned above were supplied by a variety of manufacturers, each of whom, when they got the results of the test, set to work to build tires that would make even a better showing. It must not be thought that the tire showing the highest record of efficiency, however, is that which it is always wisest to use, because in proportion as the tire is thin walled and extremely resilient, it is so much more liable to puncture. For every day use, therefore, the tire showing an average of 75 to 85 on the basis noted above would be the most practical.

There is in this connection a chance for further experimentation that should be of more or less value, and that is in the building of "balloon" tires, that is, very large ones, which will run easily over sand or mud, two road conditions that consume an enormous amount of power.

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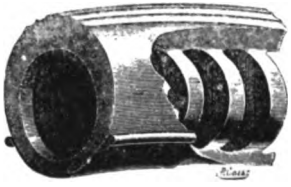
CHAPTER XVIII.

CUSHION TIRES.

IT is practically impossible to define cushion tires with any accuracy, and one is tempted to cast off the term in favor of "hybrid," which is the designation used by some makers. Still, it may be doubted whether hybrid states the case any better than cushion, so the ancient name will be used here, even though it means at once too much and too little.

Old bicycle riders will remember when the cushion tire was first brought in; it consisted of a slightly enlarged solid with a hole through the center. The hole was hardly large enough to entitle the tire to be called



LA TOURISTE CUSHION TIRE.

hollow, yet the temporary results were far superior to the solid tire. Temporary results is written here because the constant bending of the tire at the same place soon caused it to crack around the sides, until it became worthless. Nevertheless, the primitive cushion set many inventors at work, and the pneumatic tire resulted.

At first most riders were inclined to class the pneumatic as a type of cushion tire; but before they had settled on this point, it had become a case of putting the big pot in the little one. In a year or two the cushion tire had been practically forgotten, not to be brought out from its obscurity until the extraordinary strains to which the pneumatic was subjected by the automobile shook men's faith, and caused them again to consider the cushion type. Since that day the automobile pneumatic has been vastly improved; but at the same time more and more is required of it. The consequence is that there is still a real demand for suitable cushion tires for automobiles. Some people regard the pneumatic as a fair weather friend, and prefer a cushion tire that will strike a happy medium between the pneumatic and the solid. There

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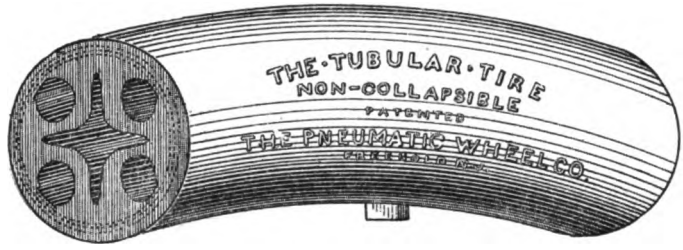
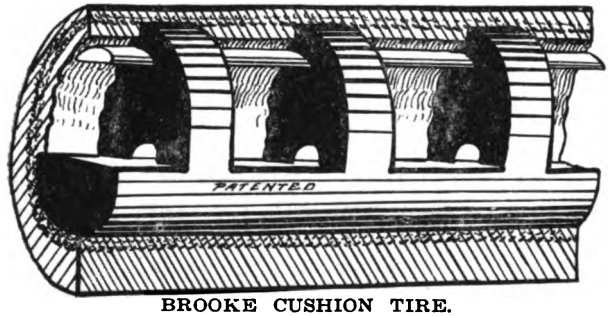
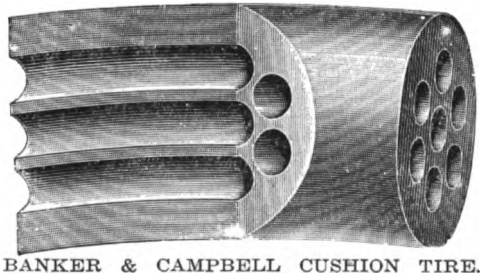
are undoubtedly those who would buy automobiles, were they thereby enabled to tour on a modest scale without the dread of tire trouble on the way. Many who are already motorists have neither the patience nor the ability to mend a tire properly on the road, with the result that they continue the run on a flat tire, though realizing that the



TUBULAR CUSHION TIRE.



BROOKE CUSHION TIRE.



BANKER & CAMPBELL CUSHION TIRE.

damage will be heavy. People who would gladly own a car, stand aghast at the possibilities of tire trouble; and though this danger is greatly exaggerated, there is undoubtedly the continuous possibility of a puncture at the most inopportune time.

In considering the tire industry, many persons divide them into solids, pneumatics, and cushions. All agree that a pneumatic must be

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inflated; but when it comes to giving the characteristics of a cushion, there is less unanimity. As a matter of fact, the divisions given are purely arbitrary, because tire development exhibits all gradations from

FAWKES'S CUSHION TIRE.

the solid to the pneumatic types. Manufacturers often find themselves at a loss how to class their tires, with the result that some solids are called cushion tires and some cushions are called pneumatics. There are

INTERNATIONAL CUSHION TIRE.

inflated types, also, which must be classed as cushions, though it is hard to draw the line, and some people will doubtless cling to the old definition under which a cushion tire was one held up by its inherent

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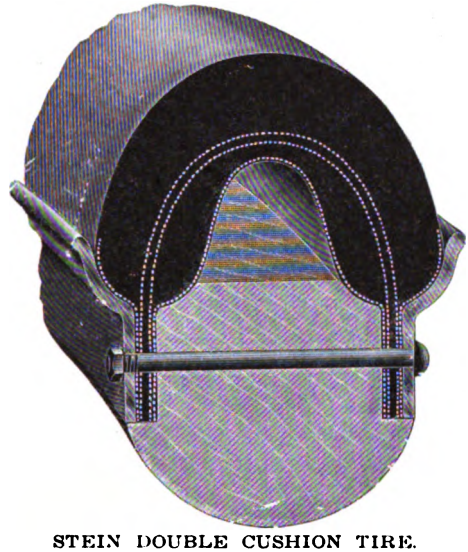
strength instead of by air pressure. The pneumatic has become so thoroughly standardized, however, that the word has come to represent this type; and any departure from the standard puts it in the cushion class.

The first cushion tires, as said, were simply hollow rubber tires with very thick walls. On account of side cracking, the hollow, which was at first made round, was varied in size and shape, in order to distribute



STEIN DOUBLE CUSHION TIRE.

the strain more evenly, and varying thicknesses of canvas were introduced, to strengthen the rubber. These features, of course, led to the pneumatic idea, in consequence of which the cushion tire was practically disused everywhere except in England. Some tolerably resilient cushions continued to be developed in Britain, all the early types of clincher being of this class. The "Sparre" tire, built on the bridgework principle, was

FISK CUSHION TIRE.

WILLIAMS CUSHION TIRE.

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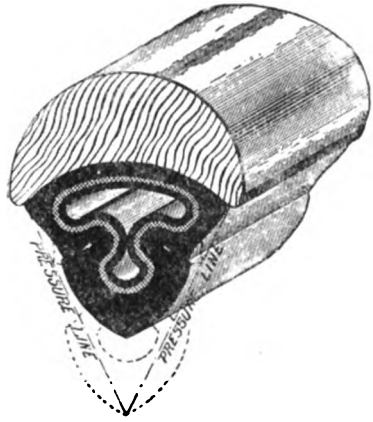
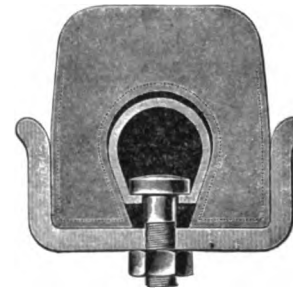
thought by many to be as fast and as easy as a pneumatic, without the skidding and puncturing proclivities of the latter. Improvements in the pneumatic, however, soon relegated all bicycle cushion tires to the scrap

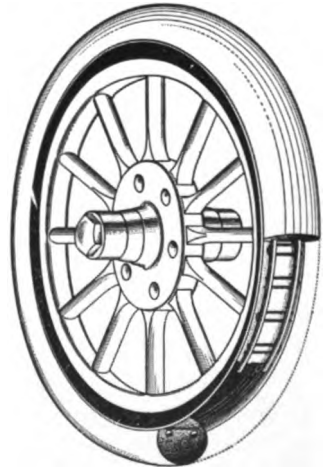


APEX CUSHION TIRE.



CLOUTH CUSHION TIRE.

heap. The shortcomings of the pneumatic became less and less, owing to improvements in detachable rims, puncture fluids, and single tubes, until it was able to meet practically all the demands upon it, so far



VOORHEES CRESCENT RIM TIRE.

as bicycles were concerned. Many types of cushion tire, however, continued to be used on light carriages, for which purpose the pneumatic has never been popular, except in the city of Paris. Most rubber tire

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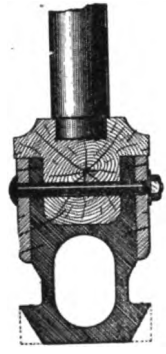
makers still make cushion tires of the simple hollow type for light horse drawn vehicles.

The coming of the motor car created a new and enormous demand for resilient tires, and they were shod with pneumatics of the regular bicycle pattern, though proportionately stronger. It was found, however, that the weight and speed of the new vehicles, together with the unforeseen strains arising from traction and side roll, made demands that the pneumatic, as built upon the lines of the bicycle tire, could never hope to meet adequately. Punctures, blowouts, pinched tubes, and



BRODERICK CUSHION TIRE.

IDEAL CUSHION TIRE.

strained walls were the rule; so that many motorists abandoned the pneumatic principle in disgust and cried out for cushion tires.

A perfect deluge of inventions came forth as a result, and the stream continues to flow. In all probability, America has done more in the development of cushion tires for automobiles than any other country, both because of its stretch of rough road and admitted inventive genius. Nevertheless they come from England, Germany, and France, some of them displaying considerable ingenuity, but most of them dull and uninviting, never getting beyond the patent offices. The demand is so strong, however, and so great are the rewards for success, equaled only by the

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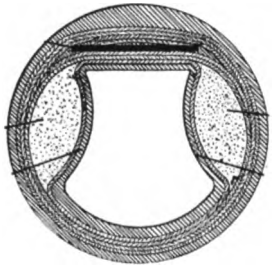
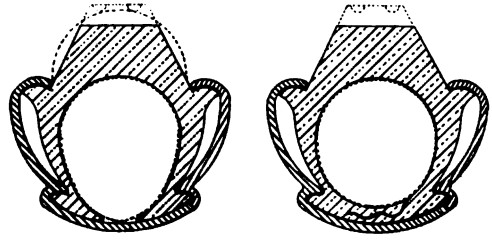
ignorance of most capitalists in regard to the mechanics of tires, that some of these inventions do actually gather capital and attack the market. Neither does the stream of inventions cease with improvements in the pneumatic; the increasing weight and horse power of the cars, the craze for speed, touring, and the increasing purchase of cars by inexperienced men, less enthusiastic than the typical motorist, and with less patience—all unite to keep up the call for a safe, conservative cushion tire that will enable ordinary persons to use the motor car for easy tripping and business purposes, without constantly consulting their tires.



TENNANT CUSHION TIRE.

BERLIN-FRANKFURTER CUSHION TIRE.



BERTHE CUSHION TIRE.

This demand, as was said, has resulted in such a number of more or less different types, that one could never hope to do more than group them into classes, based upon the sustaining principle. Some are like solids, with one or more small hollows or tunnels let into them lengthwise. Some are much like pneumatics, in form and structure, relying upon their thick walls for support. Some are simply single tubes with resilient cores of varying design, which support the weight. Some are filled with spongy rubber or with inflated rubber balls, while others contain gelatinous or rubber-like fillers. Some are solid tires with cross perforations, giving the characteristic bridgework effect, and some are a combination solid tire running upon a pneumatic located within the rim. Some are filled with cork, felt, or other springy substance, and some

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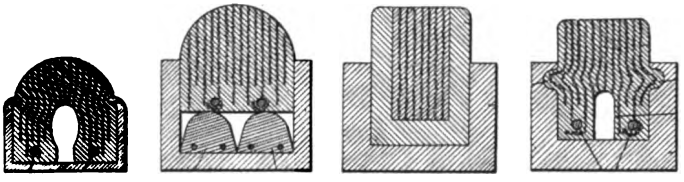
are actually made by rolling up sheets of rubber with rubber protuberances or buttons upon them. All these types are assiduously cultivated, though the most popular principle, at present, is perhaps the combination solid and pneumatic. There is a tendency to class this last type under the head of spring wheels, though they are only tires.



WOVEN WIRE CUSHION TIRE.

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CHAPTER XIX.

THE REPAIR OF TIRES.

THE repair of an automobile tire is a nuisance, but one that often becomes necessary, and the doing it properly is a trade in itself. There are professional repair shops everywhere, and this is about the only place that a tire is ever mended so that it will stay mended. A motorist may learn how to do the job correctly, but then he may also learn how to make a motor car, if he is sufficiently intelligent and diligent. If it is possible to do so, it is by far the best plan to patch a tire with a bank note; but the proper time to mend pneumatic tires is really before anything happens, an ounce of prevention being worth several pounds of cure, in such cases. The study should be not how to mend, but how to avoid the necessity.

It is probable that 90 odd per cent. of the mishaps to motor tires are not true punctures; that is, caused by sharp objects on the road, which pierce the shoe and tube. The great majority of so called punctures are due to slovenly work in putting on the tires. If they are properly fitted and kept well inflated, with perhaps a nail finder on each, the common, ordinary, smooth tread rubber tire, under a careful driver, will do good work and lots of it, and give little trouble.

A very important puncture preventive is having tires large and strong and well blown up. Remember that the rear tires have to do three or four times as much work as the front ones, and that all the tires have more to do than most people realize. It stands to reason that a large tire will ride easier than a small one, and that it will also be faster on the average road. Almost any touring car ought to have 36 by 5 inch tires on the rear wheels, and very heavy cars should use still larger ones.

There is a strong temptation to ride tires too soft, and this is the beginning of most tire troubles; but it is well to remember that, other things being equal, the larger the tires the easier they will ride. One hundred pounds pressure in a 3 inch tire will make it nearly solid, while 100 pounds in a 5 incher will be about right. As for speed, the success of the pneumatic depends upon its ability to close over stones without lifting the wheel. Where a 3 inch tire can "drink" a two inch pebble, a 6 inch tire will as easily close over a stone 5 inches through, without disturbing the car. The large tire is bound

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to be faster and easier. To be sure, the large tires practically demand a power pump, but the market is full of these. The heaviest touring cars call for tires 38 by 6 inches, or more, and with a pressure of about 125 pounds, if you want to get the best results. This pressure is about equal to that carried in locomotive boilers. Just why a tire is less liable to puncture when blown hard has not been well explained, though it seems to be proved by tests. It is perfectly simple why there should be less danger of rim cutting and of nipping the tube when running over railroad tracks.

A good large tire, well blown up, is not easily pricked by nails. Often it takes several turns of the wheel to drive the nail clear through, and if nail finders are used, the nail is snatched out before much damage is done. If leather treads are used, the liability to puncture is practically removed, though some of the resilience is sacrificed, and the leather seems to increase the injurious effects of overheating. However, these effects are not very noticeable on large tires well blown up, and the better traction and insurance against punctures make them good investments, on the whole. They furnish absolute security against flint punctures, and of course prevent small cuts in the rubber tread, which let water and sand into the canvas. The great majority of tires are never worn out really, but go to pieces from the effects of water and grit which work into the canvas through small cuts in the rubber. Even if a tire does not last as long when leather covered, the security it affords against mishap is worth consideration. The tire makers generally discriminate against them on account of their shortening the life of the tires; but if the buyer realizes this and puts their advantages against their disadvantages, the tire makers are willing to use leather covers. As for the heating tendency, the leather need only cover the tread.

Many people confidently expect that a slight improvement in waterproofing leather will make that the tire material of the future. Leather certainly has many valuable qualities. All-leather tires, even as now made, are practically proof against punctures and blowouts, the principal troubles met with in rubber tires, and leather also lasts extremely well, if it can be kept from hardening. Blowouts are the source of most trouble in rubber tires, and the hardest repairs to make. It is generally beyond the power of a motorist to handle a blowout adequately, though there are several makeshifts, by which he is enabled to reach a repair shop, if he carries no spare tire. We are becoming more and more convinced that in the various makeshifts, now on the market, lie the solution of roadside repairing. Permanent roadside repairs are practically impossible, and it pays much better to manage rightly and study how to prevent

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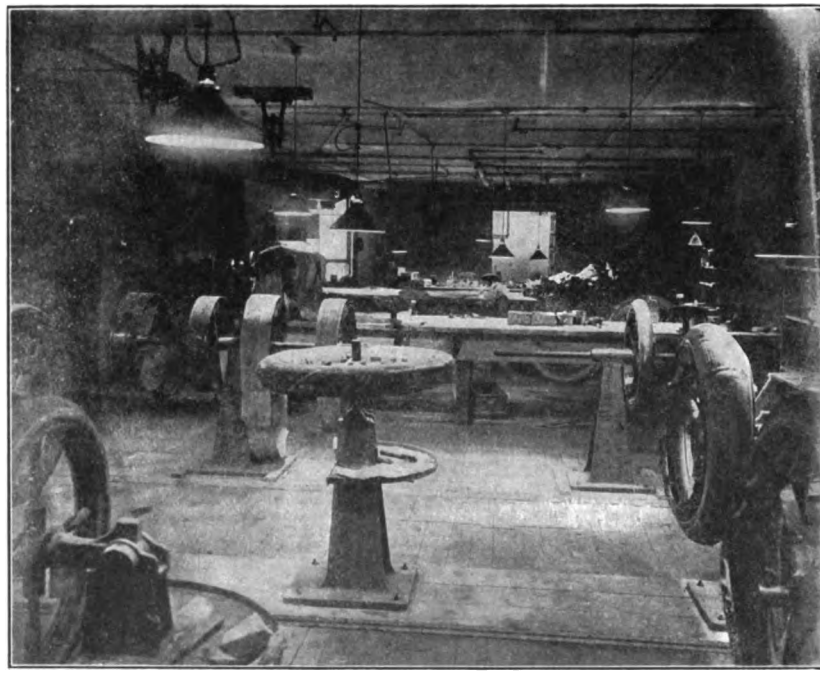
tire troubles. The repair of a big, stiff tire on the road, with only the resources of a tool box, is a heartrending task, which too often needs to be repeated within a few miles, because the patch comes off from too hasty mending. Rather than trust to a slovenly mend, fill the rim channel by wrapping rope in it until it stands above the flanges, and drive to the nearest repair shop. Such a rope filling, it is said, will carry a good many miles, with careful driving.



TYPICAL AUTOMOBILE TIRE REPAIR SHOP.

Though avoidance of mishaps should be the motorist's most profitable study, the time may come when he must deal with tire troubles himself. Then, too, there are motorists of moderate means, who can only afford the pastime by attending to the machine themselves and doing their own repairing. A fairly intelligent man can soon learn to handle a puncture and put on a patch that will hold for perhaps a few hundred miles, with careful driving. Many such persons have a mechanical turn, and really take a certain pleasure in doing their own repairing. It is even probable that this class of consumers will really form the main dependence of the automobile trade in the long run, and so all the great

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tire companies are endeavoring to teach them the details of mending, and are also sending out great masses of repair circulars, hoping to attract other persons, who are still on the line of choice, and might be persuaded to go in for motoring, if assured against repair bills, which might exceed the value of the machine.

In this campaign of education in tire mending, it seems to be the best policy to lay special stress on the various makeshifts and quick repair schemes, of which the market is so full. Many of these are very useful devices, and in calling them makeshifts, no discredit is meant. A makeshift is a temporary repair; and it must be remembered that the only way to repair rubber tires permanently is to vulcanize them carefully. Rubber cement sticks very tight for awhile, but after all it is raw rubber, which means that it is very susceptible to changes in temperature and to oxidation, under which conditions it loses more or less of its adhesive property. Vulcanizing removes all traces of the joint and makes the rubber stable in its peculiar properties, so desirable in pneumatic tires.

When a car has a very long wheel base, it is not easy to notice that a tire is running flat, especially if it be on a rear wheel, where most tire troubles occur. A more or less considerable disturbance in the steering announces a puncture in the front tire. If the air is escaping quickly, the sooner one stops the better. Even then, if the speed is rapid, the tire is apt to creep enough to injure the valve seating. If the tube was well dusted with talc when it was put in, the shoe may possibly slip over the tube and not tear out the valve. Even when the lugs have been kept well tightened, which is not always the case, the tire begins to creep soon after it has flattened.

If the tires have detachable rim flanges, and these have been well looked after, the trouble will be lessened. One has only to put in a spare tube, in place of the damaged tube. By examining the valve before taking off the tire one may be saved a good deal of trouble. Sometimes, too, a speck of dirt in the valve will cause it to leak rapidly, and many a man has wrestled for an hour taking off and putting on a tire, only to find that it was some little trouble with his valve.

There are a number of tools on the market which facilitate the removal of a clincher tire. Even with all these, however, it is not always easy. The bead may stick tight in the clincher seat, and this should first be dislodged all the way around. Either with the various patent tools, or plain levers, it is possible to take off a shoe single handed, by prizing the bead upward and outward, which brings the lever down toward one of the spokes. As a section of the bead is thus lifted up, the lever should be tied to the nearest spoke and another section gone at with an-

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RIM CUT IN TIRE SHOE.

TREAD WORN THROUGH AND SLIGHTLY SPLIT IN SHOE THAT HAS BEEN REPAIRED.

ONE TYPE OF SHOE FRACTURE.
[Inside view of a motor tire in which long use or hard use has weakened the fabric to the bursting point.]

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other lever. At times it is possible to hold one lever with the foot and the others against the leg and in the hands; but trouble will be saved if each lever is tied, as it is brought down toward the spokes. Some take out the tube by beginning farthest away from the valve, while others take out the valve first, in order to see if the trouble lies there.

Once out, it is often necessary to put the partly inflated tube under water to find the leak. The shoe must be examined, and the cause of the trouble removed, if still there. Sometimes this is not easy to find, and there are cases where the cause was a wire nail, so short that it did not reach through the tread, except when the head was sunk into the rubber momentarily by being struck with a stone in running. It is of no use to mend the puncture, unless the cause is removed or avoided.

When the prick in the tube has been located, the procedure depends upon the size of the hole. If it is a large, jagged hole, and it is impossible to get to a repair shop, one may as well prepare to spend several hours at the job. If it is quite small—the merest pinhole—there are a number of ways of mending it quickly, so that one inflation will last for several hours, at least. These methods are generally based on principles used in repairing single tube bicycle tires, to some of which a motor tube is comparable in thickness. It is mainly due to the French that this application of single tube methods to motor tubes has been made. Some of them merely thrust a thread of rubber, well solutioned, into the hole and clip it off a little above the surface of the tube; or else they soak a piece of rubber in gasoline until it swells and becomes soft enough to knead like putty. This is rolled to a point between the fingers until it can be thrust through the hole, when the part sticking through can be squeezed up against the inside around the hole, making a rubber rivet, which will do good service, if allowed to dry. Another device, called the "Comete," consists of a thin rubber disk with a short, hollow rubber tube projecting from the center. With a match stem or blunt nail thrust into this little pointed projection, it can be poked through the hole in the tube, leaving the disk outside. A buckshot is then stuck down into the tube, and this swells it out until a virtual rivet is formed, closing the hole completely. The "Cinch" repair button is a little rubber covered rivet whose parts are separable. By stretching the hole with a pair of tweezers, one-half of the rivet can be stuck through the hole in the tube, and the other is then clamped to it with a pair of pincers. The "One Minute" repair button works on the principle of two thimbles fitting one in the other. By sticking one through the puncture, the other is pressed down into it, thus nipping the rubber around the hole and closing the aperture effectually, even though the hole be as big as a lead pencil.

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If the hole be so large that a patch is absolutely necessary, this calls for a rather tedious job and one or two hours' waiting, in order to get good results. Rubber patching is founded on the principle that two clean surfaces of crude rubber will stick together. Rubber cement is nothing but crude rubber dissolved in gasoline or other volatile solvent. When it is smeared on any surface, the solvent gradually evaporates and leaves a film of crude rubber. Two such filmed surfaces, when thoroughly dry, will stick together with all the strength of crude rubber. If they are not allowed to dry thoroughly, they will not stick so well. It must be remembered, too, that in putting a rubber patch on a rubber tube, there are four and sometimes eight surfaces concerned. Two pieces of vulcanized rubber will never stick, though crude rubber will stick to vulcanized rubber and to another piece of crude rubber, if the surfaces are thoroughly clean in each instance.

The tubes of motor tires are or should be kept covered with talc powder in order to prevent their sticking to anything. All tubes are vulcanized rubber, which means that they will be covered, in addition to the chalk, with a thin layer of sulphur, which has oozed or "bloomed" out from within the body of the rubber. This may not be visible, but it is there, and it must be removed with gasoline or sandpaper or both, before the film of crude rubber deposited by the evaporated cement will stick to the tube or patch. If one must choose between sandpaper and gasoline, when removing the sulphur bloom, he should use coarse sandpaper vigorously, in order to roughen the surface of the tube and patch before applying the cement solution. The roughness is almost as important as removing the sulphur and French chalk, because it enables the cement to take a much firmer hold.

It is very important to have the best solution. After spreading it on the cleaned and roughened surface of the patch and tube, some people think it best to wipe off most of it with the finger, on the ground that a thin film will dry quicker and hold as well as a thick one. If one is in a hurry, it is well to use this method, though most people recommend the application of two thick coats of solution on both patch and tube, allowing each to dry thoroughly. If two coats of cement are used, each ought to dry at least 15 minutes before putting the patch on the tube: and if the hole is really serious, such as a small blowout, it should be patched inside as well as outside. The inside is really the proper place to mend both tube and shoe, as the strain upon the patch is much less, and the repair more efficient than when made from the outside. Patching a tube on the inside requires far greater skill, though an expert can do the job quickly and surely. By means of a little swab, the inside edges

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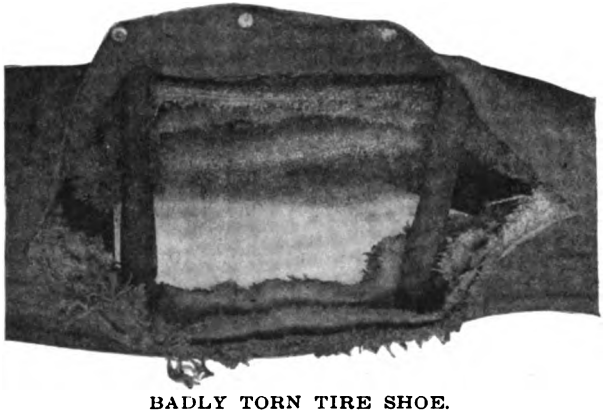
around the hole may be cleaned with gasoline. The patch to be used is then caught in the middle with slender pliers, dipped in gasoline and deftly thrust through the hole, manipulating the tube so that the patch fits well up around it. To keep the patch from wrinkling and the folds from sticking together is the whole trick; and to do this well, the inside patch should not be too large.



BADLY TORN TIRE SHOE.

[Illustration showing the extent to which a pneumatic tire can be injured by accident. The tire is practically destroyed, it being at least doubtful if it is worth repairing.]

The outside surface of the tube can not be solutioned until the inside patch has been put in and given a little time to dry. Putting on the outside patch is a much simpler task, if only one is careful to have the surfaces thoroughly cleaned and roughened before the solution is put on. One coat of solution ought to be as good as two, if it is well spread and given at least 20 minutes to dry. In a good repair kit

INNER TUBE BLOW OUT.

[Illustration of how an inner tube will blow out through a weak spot or section in a casing or shoe, brought about by puncture, or the ultimate weakening of a section of a tire.]

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there are always several patches, which have been prepared and solutioned at the factory. If these patches have soapstone on them to keep them from sticking together, this must be washed off with gasoline.

When the patch is put on, it will stick very tight at the least touch, so it must be held in the position it is to take before being laid down. It should be abundantly large, covering a good margin around the hole, and should be well rolled or hammered, to drive out any air bubbles, and to bring the surfaces into close contact. Any upcurled edges should be stuck down tight or trimmed off, and the edges of the whole patch should be bevelled, to prevent the patch from being torn off by catching in the shoe. The patch should be given as much time as convenient, so that it may dry and let the cement set. It is best to let the tube rest all night, slightly inflated, before being put in the shoe. Some repairers also recommend that a piece of friction cloth be cemented over the patch also, the cloth being cut larger than the patch, so as to strengthen its hold.

A patch so put on and allowed to dry thoroughly will sometimes stay on for weeks or months, if excessive speeding is not attempted. Continued overspeeding develops heat enough in a tire to melt crude rubber outright, and it must be remembered that the connection between the patch and tube is a layer of crude rubber. If the patch is heated to a certain degree, this film of raw rubber will melt and the patch will be blown off by the air pressure in the tube. The only way to make a patch stay on permanently is to vulcanize it on.

When the shoe has been pierced by a large nail, the hole should at least be plugged up with well solutioned cotton waste, and a piece of friction cloth pasted over the hole on the inside. In case of a small blowout, a stout cover plaster should be cemented over the inside, and a gaiter or strap buckled tight over the outside, before the tire is inflated. A ragged burst in the tread is very hard to handle, though there are a number of good tire wrappers and gaiters that will hold the shoe together pretty well if several plies of stout canvas have been glued over the burst in the inside of the shoe, to keep the tube from blowing through the tread. A blowout generally means that water has already got into the canvas and rotted it, so that plugging compounds are not very serviceable, except in fresh cuts in the tread, or in blowouts, the result of stone bruises.

Stone bruises are broken or strained places in the fabric, caused by striking a stone at high speed, when the tire is blown too tight to yield instantly. In such cases the fabric may be strained or partly broken, without actually tearing the tread rubber, so that the driver is not aware of the injury until the tire bursts later on, perhaps on a perfectly smooth road. Blowouts are always serious, and should be stepped in with fresh

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duck and vulcanized as soon as possible, since the trouble will increase rapidly, no matter how well the wound is wrapped up.

This building in or "stepping" a torn tire with frictioned duck and rubber is a very ingenious process, which has been mainly developed in England and France, though within the last three or four years an extensive business in this line of repairing has grown up in the great rubber factories at Akron and in their branches elsewhere. Tires can be retreaded in whole or in part, fabric can be built in to any extent, and sections may be taken out of the tire bodily and replaced with new sections, leaving the mended tire nearly as strong as before. To make a neat mend is difficult, but given one of the good modern portable vulcanizers, it is possible for a motorist who is clever at handling tools to make a repair that will save him $5 or $10. Sand boils and surface cuts which only penetrate one or two layers of duck are not very hard to mend, though repairing a burst cover is quite a task.

INNER TUBE TEAR.

In making simple repairs to a tire shoe, such as a sand boil, the rubber tread is cut away around the place until the canvas is laid bare. If the canvas looks injured, cut away the first layer carefully and examine the next. If it must also be removed, do not take out so large a piece, leaving a margin of fabric around each cutting, until a series of terraces or steps surround the hole, narrowing as you go down. This is what is called stepping the plies. When the fabric borders around each cutting have been scraped and cleaned with gasoline and allowed to dry, they are solutioned over and dried. Pieces of frictioned duck are cut to match each section cut out, and carefully fitted into their respective places. Abroad it is customary to sew each fitted piece to the rim of fabric left below it; but the American repairers generally find the holding power of the rubber sufficient, if the margins or steps have been made wide enough. When the fabric has thus been built up to its former level, raw rubber in sheet form is cut to fit the hole and built in until it is level with the rest of the tread. A shoe form or air bag is then put into

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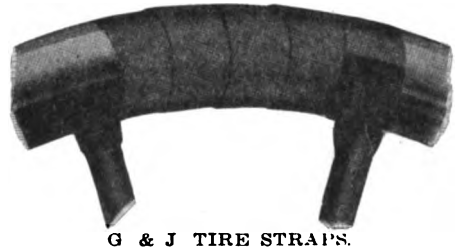
the shoe to keep its shape while baking, or the tire may be mounted and inflated instead. Asbestos paper is then laid over the tire and cut through to expose the built-in part only, so that the rubber tread surrounding the repair will not be overvulcanized. A concave plate which fits the shape of the tire is then bound over the mended part, which has been previously covered with muslin or tinfoil to keep the plate from sticking to the cured part. Either steam or dry heat of a certain temperature is then applied for a time by means of one of the many good vulcanizers on the market; and if the crude rubber sheets are of good quality and properly compounded, the tire will be found to be healed over as if new flesh had grown.

Different people have differing degrees of success with tire vulcanizing. Some of the vulcanizers now on the market are especially made for home or roadside baking, and many persons have had success with them. Many of them are entirely automatic, so that



G & J TIRE STRAPS.

the desired temperature cannot be exceeded, and in some the fuel is so accurately measured that both the temperature and the duration of the baking are automatically controlled. A slow cure is generally best, because the heat must be given time to penetrate to the deepest layers of inserted fabric without overcuring the new tread. Still, the actual time necessary to bake the plug into the tire is only about a half hour, and the repair is permanent.

Vulcanizing a patch upon an inner tube is a far simpler task. The tube around the hole is cleaned and a suitable patch of properly compounded crude rubber is cemented over it, after carefully introducing some talc into the tube to prevent the walls sticking to the patch. The tube is then clamped in the vulcanizer flat, and the job is done in 15 or 20 minutes, never to come undone. If possible, however, a vulcanized tube or tire should be given several hours in which to "set;" but with careful driving, the patch may be well powdered and used at once. French chalk or soapstone should always be put over every patch, whether cemented or vulcanized; though this is embraced in the general instruc-

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tions to powder every tube before putting into the shoe. Too much French chalk should not be used, however, because if it gathers into lumps and gets wet, it will harden into a grit that will play havoc with the tube. Its purpose is as a lubricant between tube and shoe. When any sheet of rubber is covered with rubber solution, it has a tendency to curl up on drying. If the edges of the tube curl in, as often happens, some stuff a wad of grass or cotton waste in it to hold the shape. This cotton waste cannot be taken out again, of course, but it won't hurt anything to leave it in, and it often helps in sticking a patch.

THE MODEL REPAIR SHOP.

In the repair of motor tires, hand work plays such an important part that a model repair shop can be set up with a comparatively small outlay of capital. In fact, the investment in tools need not be greater than in a country carpenter's or a blacksmith's shop. For an extensive tire

TEMPORARY MENDING OF TIRE SHOES.

repairing outfit, it is better to have a small engine for driving the buffers, grindstones, and air pumps, and to furnish steam for vulcanizing; but aside from these limited uses of power, everything depends upon skillful fingers and painstaking care.

In fitting out a model repair shop, the first thing is to get a long, wide work table with a smooth, stout top, and put it in the middle of the room. Every good workman loves a good work bench; and the middle of the floor is the proper place for it. Along one side of this bench fix several block mandrels or wooden forms of different sizes, corresponding to the prevalent types of tire used. These should be good and strong, so that when a tire shoe is hung on, one won't be afraid to do a little hammering, if necessary. These block forms fit the inside of the shoe, and are as necessary in a tire shop as an anvil in blacksmithing. All shoe repair work is done on them, from the simple opening of a sand blister to an out and out retreading. They should be fastened along only one side of the work table, leaving the other side clear. On this table is spread the canvas to receive the cement, since it is not necessary to

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buy machine frictioned duck, on account of the excellence of modern rubber solution. On this table is placed the sheet rubber and canvas for cutting into strips and stepping up the strips preparatory to retreading. On one end of the bench should be a small vise or two, and an extension bar over which to hang inner tubes for examination.

Around the walls are pegs and shelves a-plenty, because these are always useful. In one corner of the room should be a small work bench for mending tubes, with an extension bar, over which to hang the tube while patching. For replacing sections of tubes, there should be several short, different sized wooden cylinders, like rolling pins, over which the ends of the tube can be stretched for joining. A tank of water and a vulcanizer for tube work come next, with pegs on which to hang tubes before and after repairing. A vulcanizer for tube work is nothing but a small, flat topped tank, capable of holding about 70 pounds of steam, with a pressure gage and perhaps a safety valve. There are vulcanizers for sectional work on shoes, but many prefer to wrap the shoe and vulcanize in open steam. A sectional shoe vulcanizer should best form part of the outfit, unless the volume of the repair work is sufficient to justify running the open steam vulcanizer regularly.

For anti skid work it is now customary to have a riveting machine, though the work can be easily done with a hammer, if the business in skid fitting does not justify anything more pretentious. These machines run by foot power, and do the work quickly and well.

For removing the rubber from the tread, it is best to have a regular buffing machine, which consists of a shaft with an emery wheel on one end and a brush wheel with wire bristles on the other. The emery grinds off the rubber rapidly, while the buffer is needed to brush the canvas clean for the reception of the solution. In this work, as in most other parts of tire repairing, one needs several very sharp, thin bladed knives, and a bowl of water convenient, in which to dip the knife frequently. Several pairs of long bladed shears are necessary for cutting the canvas and sheet rubber.

Probably the most important single tool in the shop is the stitcher, which is simply a little fine toothed wheel fastened to a handle. This stitcher is used in retreading, in stepping in, for filling in holes in tubes, for applying leather treads, and for almost every other operation in the shop. In tube mending, a pair of slender jawed pliers is necessary to insert the inside patch. When this inside patch is deftly placed, the hole is filled in evenly from without, by pressing strips of raw rubber into it, while any unevenness that remains is shaved off smooth with a thin bladed knife dipped in water. A bowl of gasoline should be con-

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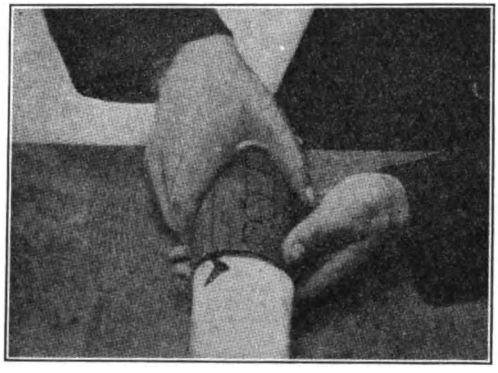
venient on the tube repair bench. For cleansing and roughening the inside edges around the burst in the tube, the buffer serves best, though they should also be sponged off with gasoline.

When patching a blowout in a shoe, it is first hung over the block form and the rubber cut through to the fabric clear around the shoe, including the bead, if a thorough repair is intended. Sand blisters may be shaved off bodily and then ground down on the emery wheel and buffed clean. The buffer is not needed in mending blowouts, because one or more layers of duck are removed bodily. For this work, the place is cut around with a sharp knife and the rubber or plies of duck separated with a chisel. In removing each layer of canvas, a margin of about an inch is left, giving the effect of steps, whence this process is called step-



EXCELSIOR PUNCTURE BAND.

ping. When building the duck and rubber in again, each layer is vigorously stitched with the little toothed wheel over every part of it. This stitching is very important; because the proper adhesion of two pieces of raw rubber demands that the surfaces be pressed very firmly together. The stitcher does this far better than a roller.

Have plenty of cement of the best quality and brush it on liberally. For vulcanizing on leather protectors or non skids, it is necessary to use the cold process, since the heat necessary to vulcanize it destroys leather. The tire should be mounted on a rim, well solutioned and the leather brought around very carefully in the position that it will take. A small spot on the solutioned surface is then brushed with the acid, and the tread leather immediately pressed down and smoothed over every part with the stitcher. The rubber solution at once becomes vulcanized.

The riveting machine needs no special description. A lever is pushed down with the foot, and the plunger thrusts the rivet through

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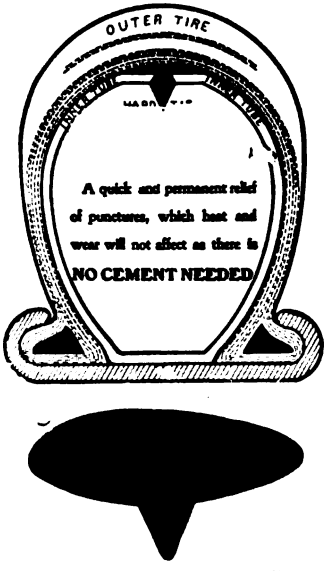
and clinches it. Power machines are hardly justified by the amount of skid treading done in the ordinary shop. A power pump and a tank for compressed air are necessary, and little muslin bags of powdered soapstone should be kept conveniently at hand, to give the finishing touches to any tire repair.

A large vulcanizer, in which a dozen or more shoes can be vulcanized at once, is a necessity in a repair shop. It is also best to use wire mandrels to hold the shoe in shape while curing. These mandrels are simply wire spirals of different sizes and lengths, to fit the standard sized tires.



QUICK REPAIR PLUG.

A coil of the proper length and size is selected, bent around and put into the shoe, after which the whole shoe is tightly wrapped with cloth, when it is ready to lay in the steam vat.

Self curing solutions are today to be found in almost all repair shops and, indeed, are put up in small quantities for the use of motorists in making quick repairs. The basis of the solution is chloride of sulphur, which is usually mixed with a certain amount of bisulphide of carbon. The whole is really based on an old invention of an Englishman named Parkes, and known as the Parkes cold curing process. For temporary repairs, and if handled wisely for permanent repairs after, it is very quick and valuable. Vulcanization by heat, however, is less likely to injure the rubber, and is better if practicable.

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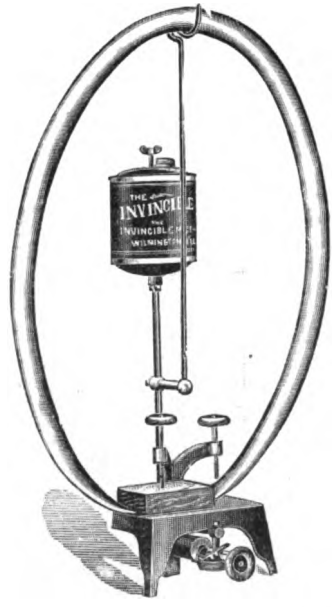
CHAPTER XX.

REPAIR KITS AND VULCANIZERS.

EVERYBODY who has tried both, knows that it is easily possible to cement a true and lasting patch upon a bicycle tube, and that it is practically impossible to patch an automobile tube so that it will stay. This is because the conditions are radically different. In the first place, the heating of a bicycle tire is unknown, and it is this heating



INVINCIBLE BICYCLE TIRE VULCANIZER.

which spoils most motor tire patches. Secondly, while a bicycle tube about fits the cover, the tube of a motor tire is much smaller than the cover, and it must accordingly stretch considerably, thus bringing a strain directly upon the cemented patch. A third important point is that a motor tube is several times as thick as a bicycle tube, and it is much easier to join together two thin pieces of rubber than to secure thick pieces. Putting on a motor tire is also a rough job, during the process of which the patch is apt to get snatched off. If the motor tire is not well inflated,

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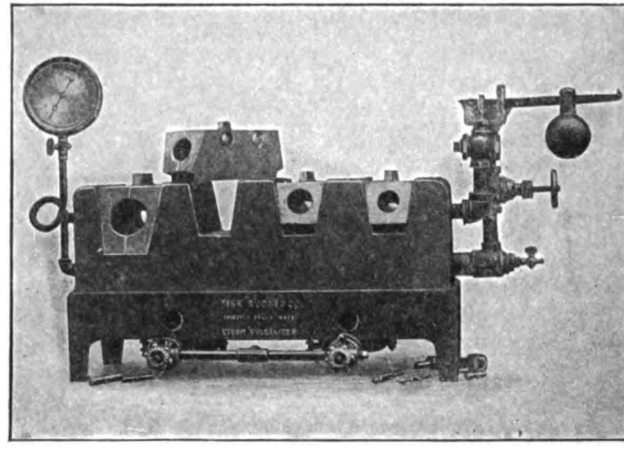
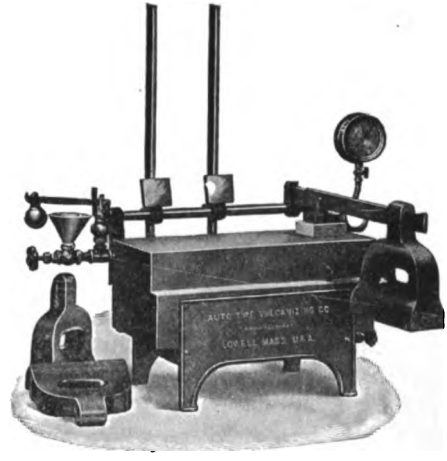
too, there is apt to be chafing between the tube and shoe. The pressure of the air in a motor tire is also nearly twice as great as in a bicycle tire, which increases the likelihood of trouble.

Alongside of these facts it is well known that dentists do a good



THE COLE TIRE VULCANIZER.



LOWELL TIRE VULCANIZER.

deal of vulcanizing with small steam generators under pressure, with which very accurate work can be done, and the process is very simple.

Putting these things together, the American and European inventors have produced a host of small steam or hot plate vulcanizers, with which

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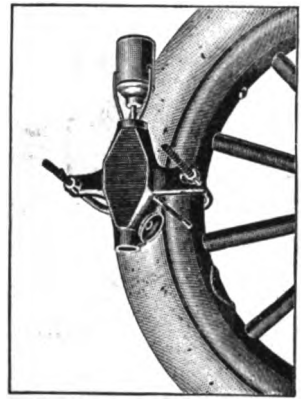
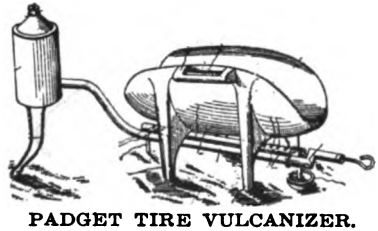
it is possible for a comparatively inexperienced hand to make quick and serviceable repairs upon either the tube or shoe of his tire. Some of the more ingenious motorists have utilized rainy days in retreading the whole of their tires, by doing which they not only saved a good many dollars, but also felt the satisfaction of having done a good work. Though these vulcanizers were at first made for the small repair shop, great



STITCH-IN-TIME VULCANIZER.

numbers have been sold, in recent years, to private owners of automobiles. They are even made so small that they can be screwed directly upon the wheel and repair a cut in the shoe without even taking it off, the whole process not taking much more time than is needed to put on a patch. The difference between vulcanizing and merely cementing a patch is that the one stays on, while the other doesn't. It is accordingly coming



PADGET TIRE VULCANIZER.

to pass that a vulcanizer forms part of the outfit of many motor cars, since they are often needed when a repair shop is unavailable.

One of the most ingenious vulcanizers in use consists of a simple flat or concave metal core, heated by electricity, and a rheostat with 25 contacts. The metal core is clamped over the patch to be vulcanized, and the current turned on. By means of the rheostat, the current may be so

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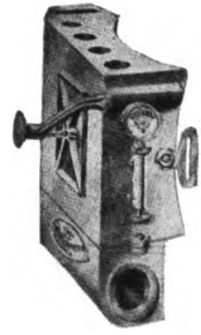
regulated that the core can be brought to and kept at any desired temperature for any length of time. However, the improbability of getting an electrical current just when it is needed restricts this machine to the repair shop or to the more fortunate private garages. The current from an ordinary electric light is sufficient, and the patch is cured in 15 minutes.



HARVEY FROST TIRE VULCANIZER.

Good portable vulcanizers have been on the market for 12 years, or ever since pneumatics came into general use. One of the earliest of these was the "Red Cross" vulcanizer, which was made both for steam and dry heat. Clamps were used instead of weights, and like dental vulcanizers, it blew off at a certain steam pressure, so that the proper heat was maintained. The dry heat vulcanizer had an arrangement of burners whereby gasoline flames could be thrown in any direction. A simpler machine, made by the same company, consisted merely of a mold and

HARVEY FROST TIRE VULCANIZER IN USE.

clamp, with a small dish underneath, which held just the amount of alcohol needed to vulcanize the patch. All that was necessary was to clamp in the tire, light the alcohol, and leave it until it was burnt out, when the job was done. Dry heat vulcanizers were also made by the Hartford, Chase, and other rubber companies, the heated air being carried completely around the tire, escaping at the top. The dry heat prin-

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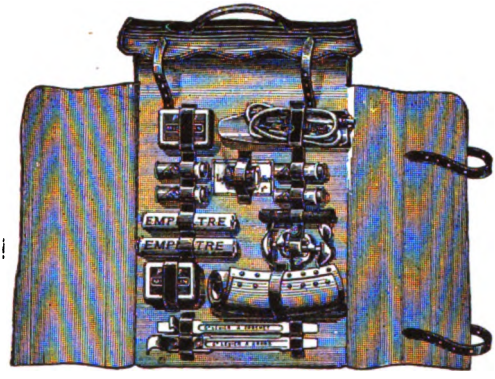
ciple is still used in the "Stitch-in-Time" and "Pig" vulcanizers. These are so small that they can be strapped directly to the tire on the wheel, the inflation of the tire furnishing the inside pressure. They are exceedingly convenient for mending small cuts before sand and water can get in to give further trouble.

Dry heat vulcanizers can be made to do the work very well, but there is some prejudice against them, since they generally require careful watching. The great majority of vulcanizers are consequently made for steam heat, which can be regulated better than dry heat, and is less apt to burn the rubber. Steam vulcanizers generally carry a pressure gage, a thermometer, and a pop valve, which blows off above the critical temperature. They generally use weights instead of clamps to



MICHELIN COMPLETE REPAIR KIT.

get the pressure upon the tire. For repair shops, they are made to vulcanize as many as 10 tires at once. The time for vulcanization is variable. When the steam pressure is 80 pounds, the time is 18 minutes, for some machines, and 20 minutes for others. One company calls for 57 pounds of steam to be maintained, 20 minutes for bicycle tires, and twice as long for motor tires. Many prefer low steam pressure, on account of the fancied danger of boiler explosions. The Cain vulcanizer claims to use superheated steam, which, at 50 pounds pressure, gives a temperature of 315° F. Harvey Frost & Co. generally advise 60 pounds steam pressure, though 50 pounds and 70 pounds are recommended for certain classes of work. This heat is kept up for from 15 to 40 minutes, according to the thickness of the tube or shoe. They figure that 80 pounds of steam gives a temperature of 275° F.

Many persons find hot vulcanizing too inconvenient, and prefer the various cold cure processes now on the market. With this process, it is

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generally sufficient to first cement the parts, and when this is dry, to brush the surfaces with the patent solution and then press them together, when the vulcanization is accomplished. The "Ara" process, much used in England, makes use of a rubber solution in which it is claimed that the rubber particles are surface cured, so that they will adhere and form a vulcanized patch or plug, on being welded by an "extruder."

Vulcanizing is not the only thing that needs to be done in the care of tires; and a touring car must carry a repair kit with everything in it likely to be needed on the road. The repair kits furnished by most of the great motor tire makers contain only the smaller articles, such as scissors, emery cloth, patches, sheet rubber, frictioned fabric, tape, cement, valves, lugs, pliers, etc. But in addition to these, there are many other larger articles, such as wheel jacks, an ever growing list of tools for removing clincher tires, pressure gages, pumps, talc, spare tube, inside and outside tire sleeves, non skids, wrenches, bolts, wire, rope, string, and so on.

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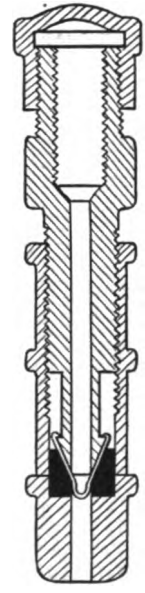
CHAPTER XXI.

VALVES FOR PNEUMATIC TIRES.

SOME kind of valve is, of course, essential to the use of inflated tires; but after all the requirements are simple, and most of them do their work fairly well. The valve idea is very old, indeed, and those used in blowing up various rubber receptacles were practically



DURYEA TIRE VALVE.

[The cut makes the construction of this valve very plain. The cap simply protects the threads and keeps out dirt. The removable seat can be unscrewed without taking off the cap and when removed leaves a free passage through the air tube with its vulcanite seat. The check is loosely retained on the point of the removable seat at all times. In the cut the valve is shown closed.]

perfected 80 years ago or more. In its outward appearance, the valve used by Thomson in 1845 for inflating his pneumatics looks very much like those used now. In fact, the pneumatic valve can hardly be said to have a history, so far as our purposes go.

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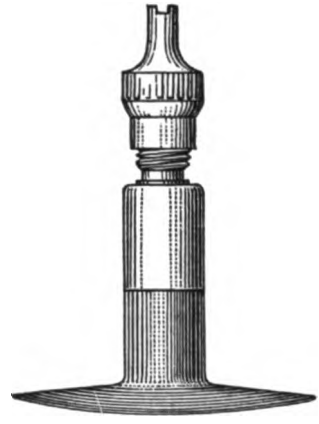


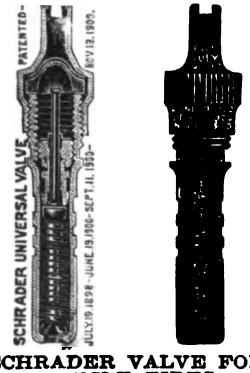
COMMON TYPE OF CYCLE TIRE VALVE.

The bicycle valve grew out of the older air cushion type, and the automobile valve is merely an enlarged bicycle valve. In early years practically all the valve improvements came from Germany.

Before the bicycle was largely displaced by the automobile, little was heard about valves. The Schrader valve was universally used on bicycle

SHOE STYLE WITHOUT RIM NUT

SCHRADER SHOE VALVE WITH RUBBER WASHER.
[Used in valve repairs for single tube tires.]



SCHRADER VALVE FOR BICYCLE TIRES.

tires, in America; consequently, there was no general education in the merits of this or that valve, as was the case in every other feature about a wheel. It sometimes became necessary to have another valve put in, but this job was generally given to a regular repairer, without instruction on this point, and the price was counted in the bill.

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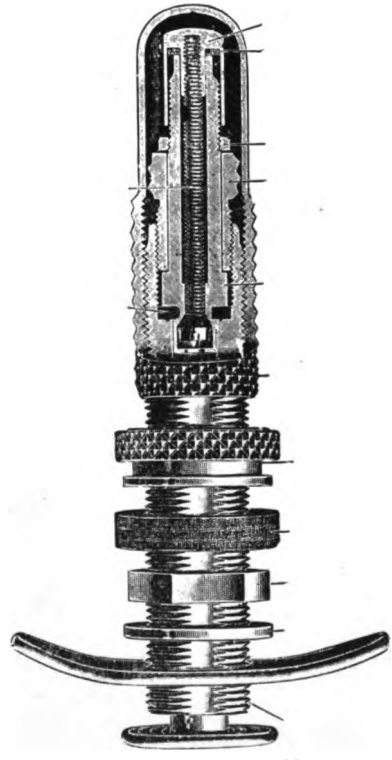
It might be said as a general rule that valve troubles are not usually the fault of the valves themselves. Such troubles are generally due to the tire creeping and straining the joint with the tube, and real valve failings are generally caused by punching things against the plunger or by leaving off the cap, allowing dust and dirt to spoil the contacts. Occasionally, however, the spring will go wrong, or the rubber washers inside will soften and become enlarged. These parts can always be bought separately, and they can be replaced by any handy man.



MACINTOSH VALVE—ENGLISH.

Valves have always been expected to leak a little, but the rubber washer in the cap practically stops this. The plunger or valve cone will also stick, sometimes, and has been known to freeze tight; but it is seldom difficult to release the plunger, and if frozen, a few strokes of the pump will warm the air enough to thaw it out. It has been the experience with many valves that they keep the air out as well as keep it in, especially in the case of automobile valves. When the spring is tightened too much, it may require considerable effort to drive the air in past the check.

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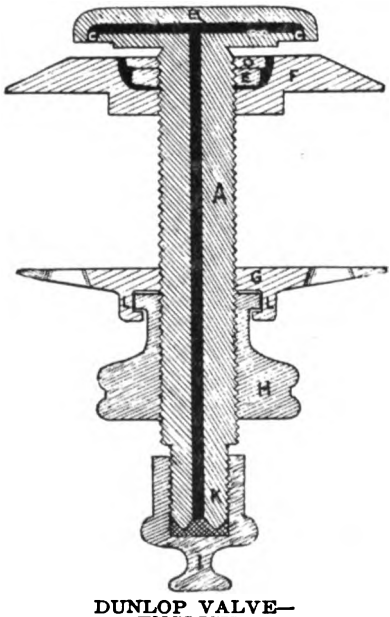
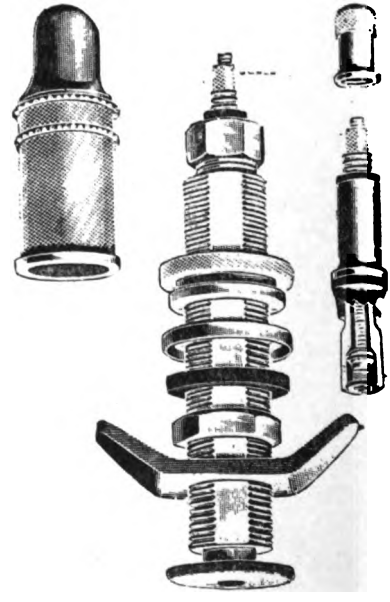
Most people want 70 or 80 pounds pressure in their tires, and factory tests indicate that many valves require a pressure of 50 pounds to open the check and drive the air in through the narrow, winding passages in the body of the valve. Thus, the valve and the friction in the pump itself often double the work of inflating. This does not mean much, in the case of pumping a cycle tire, but it is a serious consideration, when it is necessary to stuff 80 pounds of air into four 36 by 5 inch tires, such as are used on many touring cars. Here is where the power pumps come in. When the use of a hand pump is necessary, it is possible, in the case



DUNLOP VALVE—
ENGLISH.



BERLIN-FRANKFURTER VALVE—
GERMAN.

of many valves, to lessen the work by unscrewing the valve seat and check. It is rather a pity, too, to depend to any extent upon the valve cap to help hold in the wind, but nearly all valves have this failing.

The typical tire valves consist of a metal tube which fits air tight in a rubber tube vulcanized to the inner tube of the tire. This metal tube, which is the body of the valve, has in it a valve seat screwed into position, the seat having an air passage through it. At the inner end of this air passage is the check, which is really the valve proper, valve being merely the Latin for a door. This check may be a cone, a flap, or a ball, or any other device for automatically closing the opening. Sometimes the pres-

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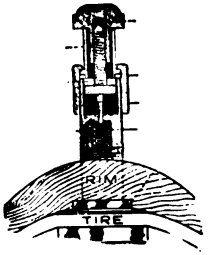
sure of the air inside is relied upon to close the check, but it is generally customary to have a little spring to bear upon it, so that the air passage will remain closed until the pressure from without is greater than the combined pressure of the spring and the air inside. The check, of course, is the critical point in the whole valve design, and it is not easy to make the contact so true that no air escapes. It is usual to have



PALMER VALVE.

one of the contact surfaces of some yielding material, like rubber or leather, these being the washers or gaskets. For fear some of the air might leak around the valve seat, another washer is used where it screws into the valve tube. Then again, lest some of the air might get

SCHRADER SHOE VALVE
FOR DUNLOP TIRES.

SCHRADER SHOE VALVE
FOR G & J TIRES.

by the check, owing to the contact being broken by particles of dust, or to a slight unevenness in the surface of the washer, the cap, which is screwed over the outer end of the air passage, is generally provided with a washer, which is screwed down tight over the opening.

The standard valves follow in the main, the principles outlined. There have been others of a radically different design, nevertheless. A

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great disadvantage in the standard valve type is the fact that it necessitates cutting a hole for it through the rim. This weakened the rim very considerably, in the case of bicycles, but it is not much of a factor in the case of automobile rims. Valves have always been a source of trouble, however, in the case of tires creeping. Great precautions are needed to prevent this, or the valve stem will be quickly strained or torn off the tube. In the case of single tube tires, this trouble is particularly feared, leaks around the valve stem being very hard to heal.

To meet these difficulties, several makers, for instance the Clark Cycle Tire Co., of Boston, made valveless tires. In order to fill them, a hypodermic needle was stuck into the tires, and air forced through. Small self sealing pockets were introduced into the tire at one or more

FLEUSS VALVE.

BOWE VALVE.

places during its construction. The needle was thrust through at one of these pockets, the spongy substance inside acting as a valve when the needle was withdrawn. Several valves have also been made, designed to enter the tire on the side, thus obviating the necessity of boring through the rim, and avoiding the customary dangers from tire creeping. One of these side valves, known as the Picket "all rubber" valve, attracted considerable attention, on account of the boldness of the idea and the simplicity of its design. In principle it was a rubber rivet, with an elastic stem, whose tension held the inner head or button tightly over the opening. When inflating, the outer head was drawn aside, and the nozzle of the

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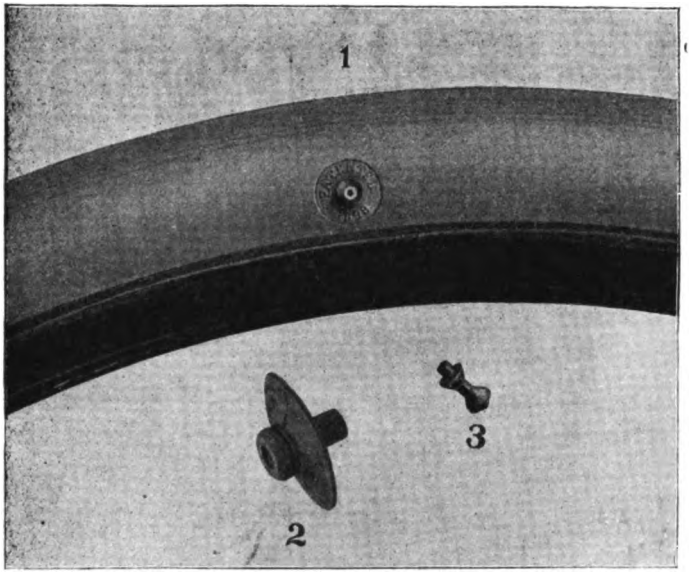
pump thrust in alongside the elastic stem. The principle was ingenious, but this valve never came into extensive use.

An interesting type of valve, represented by the Bown Tire Valve Co., has for its check a small rubber ball instead of a metal plunger. This greatly simplifies the construction of the valve, and leaves practically nothing to get out of order. As a matter of fact, however, reliance is placed almost wholly upon the cap, in the very specification. When the cap is screwed down tight, a slight leakage around the ball soon equalizes the pressure, so that the ball drops back from the opening, throw-



THE PICKETT ALL RUBBER VALVE.

ing the full pressure upon the dust cap. As a rule it is not considered well to have the check depend wholly upon the back pressure, and as long ago as 1892 the Silvertown pneumatic tire valve was held in particular esteem because it did not depend on back pressure for its closure.

Some very ingenious valves have been invented, which automatically register, regulate, or announce overpressure in the tire. One of these, made by A. Ferdinand, of France, has a secondary set of springs, by means of which, when the pressure becomes too great for safety, the entire valve seat is forced upward. In the hub of the wheel are a small battery and a bell, with wires connecting with the valve seat and the dust cap. When the excessive pressure drives the seat outward, the circuit

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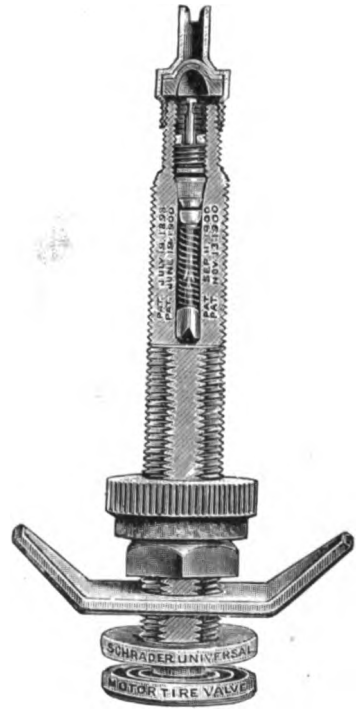
is closed, and the bell rings until the motorman relieves the pressure. The Arnold tire safety valve, instead of registering the pressure or sounding an alarm, actually relieves the pressure automatically. This valve has two checks, working in opposite directions. By adjusting the spring the valve can be regulated to any pressure. When this pressure is raised by high speeding, or heating the tire from any cause, the safety



SECTIONAL VIEW OF SCHRADER VALVE FOR AUTOMOBILE TIRES.

check is opened and lets out some of the air. Thus the strain is relieved, and blowouts may be prevented to a certain extent.

The Arnold valve is for use while running; but the "Lock Switch" tire pressure gage is useful only while inflating. It is really no permanent part of the valve, but is rather a nipple interposed between the valve stem and the pump tube. This nipple is provided with an escape valve and spring, by adjusting which with a screw the air pressure within the tire can be set at any point marked on the scale. Beyond this point no further air can be forced through the valve.

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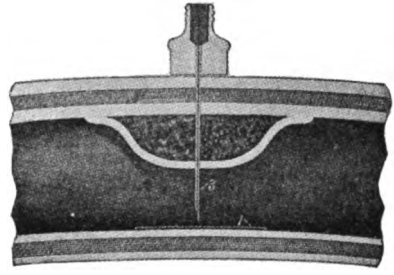
A valve suggestion, which really abandons the valve idea in favor of the stopcock principle, is the Duryea. The check, in this case, or what corresponds to the check in other valves, is an aluminum cone fastened loosely over the opening of the air passage in the seat. When inflating, the seat is screwed up, leaving a free passage for the air. When through pumping, the seat is screwed down, forcing the cone against a vulcanite counterseat, thus closing the passage.



THE CLARK VALVELESS INFLATOR.

It will be sufficient to merely mention that some of the new French detachable rims need a special valve, the only requirement being that it shall not extend through the rim. Otherwise they embody the regular valve features.

To summarize, the valve, that is the ideal valve, is a very simple proposition. A perfect check, a perfect cap, and easy accessibility is all that is needed. All of these qualifications seem to be possessed by the American valves. It is a curious fact but all of the American tires today use Schrader's, and the makers have brought out a new type that is interchangeable with the leading makes of European valves, so in the near future the Schrader parts will doubtless take possession of the whole valve world.

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CHAPTER XXII.

PUNCTURE FLUIDS.

NOTWITHSTANDING all the opprobrium heaped upon them, puncture fluids serve their purpose in very many cases, particularly for cycle tires. These fluids came into existence at about the same time in America, Great Britain, France, Germany, and Switzerland. They flourished for a time, and then the trade became less brisk. However, those who have been successful in securing the best are still strong adherents, and others who have been on the opposition side are watching with interest a recent revival of the trade.

Among the fluids that have been used, first is the Glines liquid rubber. It is said to be a solution of pure rubber, which, injected into the tire, quickly finds its way to the defective spot. The process of hardening immediately takes place and the repair is completed without the use of plugs. Then came the Dunlop puncture stop, which consisted of a sticky fluid to be injected into the inner tube. In this fluid were small granular particles, and when a puncture occurred, these particles, attempting to escape, were conveyed to the opening, which it was presumed to stop. Another English quick-drying vulcanizing solution was the "Hermetic stopping." A little of it applied to a puncture becomes vulcanized by atmospheric action, several layers being put on until the desired thickness is acquired. Still another English compound is "Araline," in which are tiny particles of rubber, having been first partly vulcanized. By pressing these particles into any aperture they become welded into a mass of cured rubber.

A German inventor has patented a jelly made of glue to which glycerine is added to prevent hardening, and an antiseptic preparation that keeps it from fermenting. The mixture, when applied, has to be heated until it liquifies, and then beaten to a foam. It is introduced into the tire when it is in this frothy condition, which is followed by solidification. The result is a light substance of cellular formation.

"Everlastic" is a substitute for air and by some considered a good compound. As a liquid it is forced into the tire until the desired pressure is reached, and in a comparatively short time it coagulates and is said to become like rubber. It is not affected by heat or cold, and the claim is that it will last until the tires and inner coverings of canvas are worn out.

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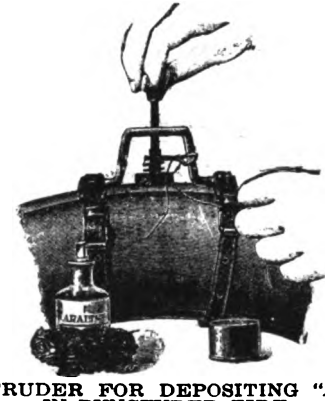
"Cyco" is a popular compound, said to serve as a preserver of tires as well as healer of tire wounds. It is made of vegetable gums that will not harden; neither will it interfere with vulcanizing in the event of a large rupture.

"Elastic tire filling" is supposed to resemble pure gum rubber, with nearly the same amount of elasticity. After prolonged runs at high speed tires become heated to a temperature of from 100° to 180° F. It was with the object of finding ingredients for a preparation that would not be affected by this intense heat that Elastic filling was prepared. Through repeated efforts the last difficulty was overcome and a solution was placed upon the market that had the recommendation of not remelting.

"Anti-puncture" is one of the best known fluids. It is forced through the air valve and adheres to the inside of the tire, where it remains stationary and does not flow. Being elastic and spongy, it is designed to fill small or large punctures and prevent the air from escaping.



EXTRUDER FOR DEPOSITING "ARA" IN PUNCTURED TIRE.

A sugar solution is recommended by some. One rider, who has been highly pleased with the results obtained, suggests the following method of treating tires: Fill an egg cup with light brown sugar and press down gently. Then fill the cup with boiling water and stir until as much of the sugar as possible is dissolved. It is injected through the open valve stem, leaving, of course, the sediment. This is sufficient for one tire. After a few miles on the road the effect becomes apparent, the sugar then having time to spread. Demerara sugar was used by the person giving this formula.

For a porous tube an English journal recommends the injection of a tablespoonful of stout or porter, this stimulant having proved efficacious in the experience of the writer.

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A self repairing pneumatic tire, first placed on a French market, has a wall about ⅜ inch thick composed of fabric and different kinds of rubber. The inner layer consists of crude rubber which is adhesive and immediately stops any puncture. When it is desired to inflate, the driver simply punches a hole through the tire by means of a special needle fitted to any ordinary tire pump, and the pressure may be pumped up to the required point.

Another tire compound is made of glue and molasses in which three pints of molasses to one pound of glue is used, and one-half pint serves for a single tube tire 28 by 2½ inches. The mixture is heated in a glue pot with water bath, and when liquified is injected into the valve opening by a foot pump.

Of course, the chief objection to puncture fluids is in the chemicals they contain and the effect their use has upon future repairs, though for a present need they are often productive of good results.

The following is a summary of the principal puncture fluid compounds which have come into use up to date:

Typical French anti puncture fluid: Silicate of soda, sugar, dextrine.

Typical English anti puncture fluids:

No. 1.	No. 2.
Glue.	Melted india-rubber.
Glycerine.	Chalk.
Water.	Meal.
Chloroform.	Glycerine.

No. 3.	No. 4.
Pyroxylin.	Sugar.
Amyl acetate.	Starch.
Amillic alcohol.	Plaster of Paris.
Glycerine.	Water.

Typical American anti puncture fluids:

No. 1.	No. 2.
Glucose.	Graphite.
Whiting.	Asbestos powder.
Carbolic acid.	Magnesia.
Oil of Mirbane.	Glycerine.
Water.	Water.

No. 3.	No. 4.
Boracic acid.	Gum arabic.
Caramel.	Flour.
Dextrine.	Glucose.
Water.	Water.

These show the general composition which was designed to produce a non drying fluid carrying minute obstructions that, forced by air pressure

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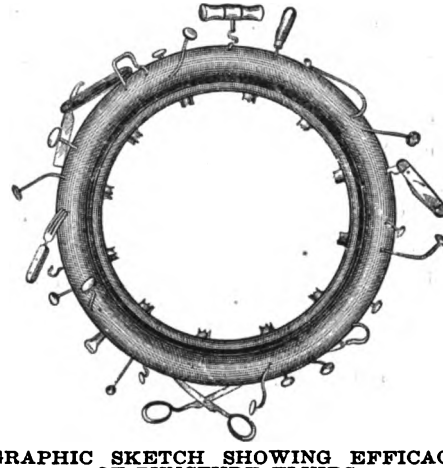
into the puncture, formed a clot and made the tire air tight automatically and instantly.

There is this to be remembered in them all, however: that any substance that can be pumped into a tire through a quarter inch valve will probably burst out through a quarter inch puncture.

So far the puncture fluid has not appealed very largely to the users of automobile tires. A recent invention, however, along the line of puncture fluid ideas and yet radically different, has been very thoroughly



GRAPHIC SKETCH SHOWING EFFICACY OF PUNCTURE FLUIDS.

tested in and about New York. It is an inner tube which contains a shallow pocket extending the full length of the tread portion, and in this pocket is some viscid material in which floats a peculiar long fiber. The writer witnessed many experiments in puncturing this inner tube which was in a tire on one of the front wheels of a heavy touring car, and after 15 punctures made with awls and nails the tire was still air tight. Of course, this type of tube is to be tested out for lasting qualities and for the unusual accidents that rubber goods indulge in, and until then it would be unsafe to say that the puncture problem was solved.

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CHAPTER XXIII.

INDIA-RUBBER AND GUTTA-PERCHA CEMENTS.

THE rubber man who does not know how to make almost any kind of elastic cement would be hard to find. Indeed, there was a time when rubber itself was made up into a cement before being converted into mechanical goods, as the time of large washers, mixers, and calenders had not then come. In the gossamer factories, where the "churns" were set in rows of a dozen or more, and where iron arms were daily whirling through the sticky mixture to reduce the compounds to the right sort of coating, it was no trick to make a cement.

In the first place, let us look at what a cement must do. To begin with, where two surfaces are to be joined, the cement must be in contact with both edges or surfaces. Very frequently in rubber work, instead of using cement, the two surfaces are simply brushed over with naphtha. This softens the rubber, and when partially evaporated leaves it in nearly as favorable a condition for adhesion as if cemented.

As a rule, as little cement as possible should be left between the surfaces which are to be united, and, in addition to this, all cement should be given plenty of time to dry. Rubber surfaces that are to be joined should be brushed lightly with thin cement, and then, if practicable, laid where they are exposed to a gentle heat. This both softens the rubber and evaporates the solvent. When the surfaces can be touched with the finger without having any particle of cement adhere to it they can be joined with good results. A premature joining of material newly cemented sometimes produces both porosity and blisters.

The rubber cement should always be similar to the mixed sheet upon which it is to be used. That is, it should contain the same percentage of sulphur. If care is not taken that this is so, strange results are attainable in the vulcanization. On every can, tub, pail, or dipper in use for holding cement should be graven the ancient direction, "Well shaken before taken," or let it be thoroughly understood that much defective work comes from "thick cementing" where the sulphur, etc., have settled.

In large manufactories, where great quantities of cement are used, machinery is employed to take the place of the "stirrers." A machine is in use for this purpose, consisting of a huge tank, not unlike a hogshead in shape, in which revolves a wheel that looks like an inverted turbine.

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This, running at high speed through the conglomeration of stickiness, mixes a large quantity in a short time.

It is admitted in all manufactories where the article is used that cement is a dangerous servant. The owners fear it; the operatives dislike it, and the insurance agents dread it. It has, therefore, come to pass, that in most well regulated places the mixing and stirring of cement has been done in a fireproof building, known as the "cement house." This may be near the factory, so as to receive the benefit of the steam power, and yet be so distant and protected as to be harmless either from sudden explosion, or fire from any other cause.

Among the many cements used in rubber manufacture, one that has become famous is the marine glue. The common way of making it is one pound of caoutchouc to one gallon of coal tar naphtha, and 20 pounds of shellac. This is heated gently, and poured upon metal plates to solidify; when needed for use it is melted at 250° F. This cement is insoluble in water, and, in most cases, makes the broken place stronger than the surrounding parts. By using more naphtha the same may be obtained in liquid form.

A good gutta-percha cement may be made of two parts of common pitch, one part of gutta-percha, melted together and well stirred, then poured into cold water. The result is a hard brittle substance, which, however, softens when heated, and at 100° F. is a thin fluid.

The basis of any good cement used in the tire manufacture, repair, or application of tires is either india-rubber or gutta-percha. Usually it is the former, and this is supplied to the user in the form of solution, the most common solvent being benzine. There are great varieties of rubbers that can be made up into cements as there are a good many varieties of solvents. For example, many formulas that go the rounds of newspapers mention bisulphide of carbon, chloroform, and ether as good solvents, and they are, but altogether too costly for ordinary use.

It is not to be understood that a good cement of necessity be made only of Pará rubber and naphtha. There are various other ingredients that are necessary. For a quick drying cement specific driers must be added, and where certain degrees of tenacity are needed other gums are added, such as rosin, mastic, gumlac, etc. The automobile tire, of course, is not attached to the rim by cement. The single tube bicycle tire, however, is very generally attached in that manner, the hard cement generally used having a gutta-percha base and being softened by heat before it is put in use. Bicyclists have long claimed that it has been very difficult for them to get satisfactory cement. This is in part because those

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who apply the tires buy the cheapest that can possibly be discovered, and it acts only as a temporary stitcher.

It is interesting to learn that some of the foreign government requirements insist that the solution shall contain not less than 18 per cent. of rubber, and one wonders what the rest of the compound may be as the solvent nearly disappears. Many tire cements—that is, bicycle tire cements—contain a great quantity of resin and only 8 or 9 per cent. of rubber, and if they are of a nature that doesn't dry out too quickly they seem to hold fairly well.

Cements for repair men should, as a rule, be bought from tire manufacturers if possible, the reason being that the compound used in the cement will be very similar to that of which the tire is made and will cure much better than if not thus prepared. It would be very easy to quote many hundreds of cement formulas, which perhaps would tempt tire repair men to make their own cements. That, however, is inadvisable, because those who manufacture such products on a large scale and in a variety are far more capable of producing a satisfactory article than could be done by a layman.

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CHAPTER XXIV.

SOLID VEHICLE TIRE MANUFACTURE.

HOW the ordinary solid carriage tire is made is a mystery to almost all except those who believe rubber is melted and cast, and they, of course, are wrong. Rubber is cast to a degree, that is, in the form of a plastic dough. It is pressed into a mold and baked under pressure. But how is the solid tire shaped to fit the mold? The answer is, by means of a machine known in England as a spewing machine, and in America as a tubing machine. It is simply a great screw revolving inside of a steel tube that looks not unlike a small cannon. At the mouth of this cannon is an opening shaped for the tire, while through it run spindles that make the holes for the wires. The rubber dough is fed into the breech of this cannon, and "spewed" out of the muzzle in a form that just fits the mold in which it is baked. Of course, for the huge tires that are today used in heavy trucking this process is varied, but the dough form as a beginning and the baking as an ending are just the same.

The vulcanizing molds and presses for solid vehicle tires take a great many different forms. For example, one American company vulcanize all of their tires in circular form so that they fit the channel of the wheel without any distortion at all. An English company have a curious adaption of this whereby the tire is molded endless but in the form of a double "S," which is supposed to have an especial value. Then, too, there are press molds in which many lengths of solid tire are laid and vulcanized like a huge sheet of raised matting. There are also automatic molds and presses with knuckle joints that are said to be great labor savers. Perhaps the most ambitious attempt at labor saving and at doing the business on a large scale is what is known as the Shaw solid tire system. This does all of the handling mechanically and incidentally accomplishes very much more. The apparatus described very briefly consists first in overhead cranes for handling the molds, both before and after filling, and for transferring them from the preparing tables to the mold cars. These cars are double deckers, and the top of each deck is a system of rollers on which the molds rest. The vulcanizer is practically a hydraulic press and steam vulcanizer combined. Instead of being fitted with tracks it has rollers which are revolved either toward or away from the vulcanizer, and by a clutch arrangement revolve also the rollers on

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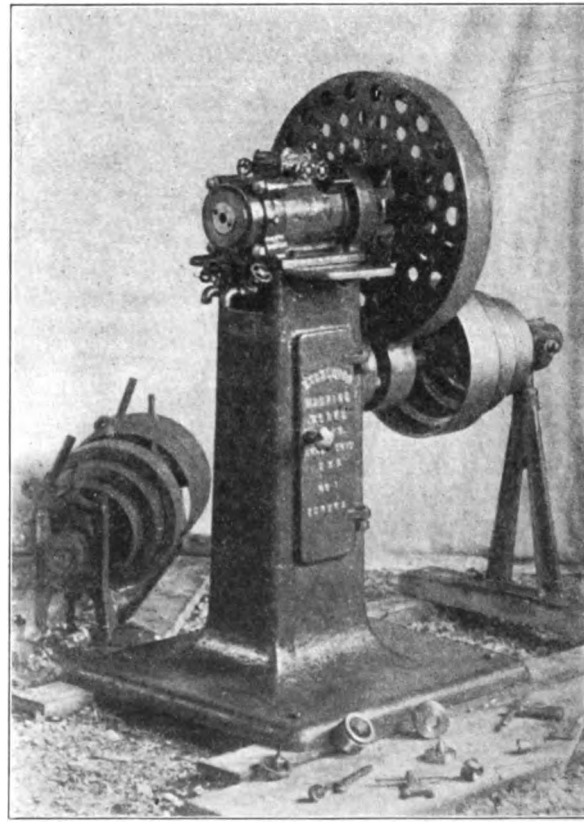
the car, thus moving the molds into the vulcanizer. Once in place a series of hydraulic rams under the vulcanizer are raised, closing the molds, pressing the rubber and holding all in place, while the cure is effected by turning live steam into the vulcanizer and making it in reality a live steam cure. The object of the double decked car is to allow a heat of molds that has just been discharged from the vulcanizer to be lowered



SPEWING MACHINE FOR FORMING SOLID TIRES.

into the cooling pit while still on the car, while another charge is rolled from the upper deck into the vulcanizer. There are a great variety of lesser devices in connection with this system, all of which are simple and decided time savers.

Today carriage tire stock for ordinary buggies is run in almost continuous lengths and is finished and wound on reels so that the carriage

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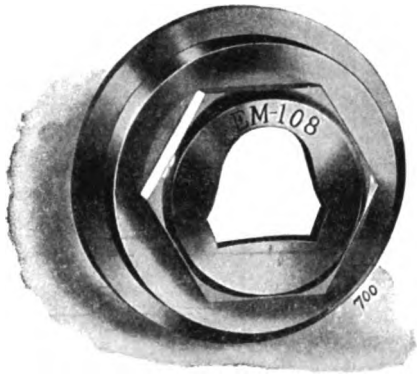
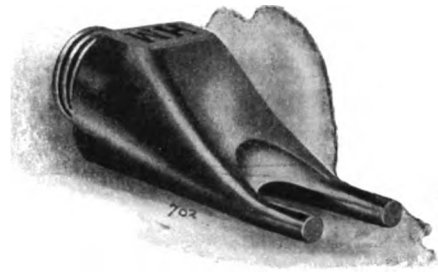


DIE THROUGH WHICH RUBBER IS FORCED TO GIVE A SOLID TIRE ITS SHAPE.



DIE THAT OPENS HOLES FOR WIRES IN SOLID TIRES.

man can cut off any length he wishes without waste. When it comes to the manufacture of tires for heavy trucks, motor 'buses, etc., the whole of the work is much more intricate, and compounds and vulcanization much more difficult to handle evenly and successfully. This can readily be understood when one sees one of the huge single or twin tires in cross section and observes the mass of rubber that must not only be thoroughly vulcanized throughout, but must be of a dense, tough, wearing quality, and resilient. Whether the limit has been reached on huge truck tires is the question. At all events, the rubber manufacturers of the world today are ready to build solid tires for any purpose whatever, and in many cases to guarantee them for definite service for a reasonable period of time.

DISTINCTIVE FEATURES OF THE LEADING TYPES OF SOLID TIRES.

It is uncertain when or where solid rubber tires were first used for the wheels of carriages. Doubtless the honor of being the pioneer would be found to have many claimants. But the use of such tires was nowhere general until they were taken up by The Shrewsbury and Talbot Noiseless Tyre and Cab Co., Limited, and applied to their extensive service of new hansom cabs on the streets of London. The tire adopted was that of Carmont's patent of 1881, and his improvement of 1883—a rubber tire held in a rolled steel channel in a state of compression, between converging flanges. London being well paved, and the traffic referred to being light, the rubber tires gave widespread satisfaction, so that within a very few years it was estimated that 10,000 sets were in use in that city.

The Carmont tire was introduced in America by the late Channing M. Britton, who had been a fellow student with the Earl of Shrewsbury

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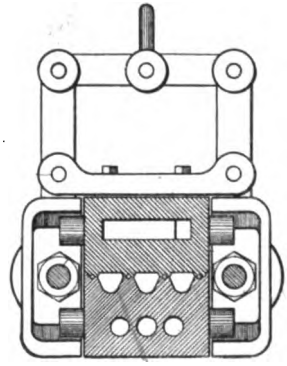
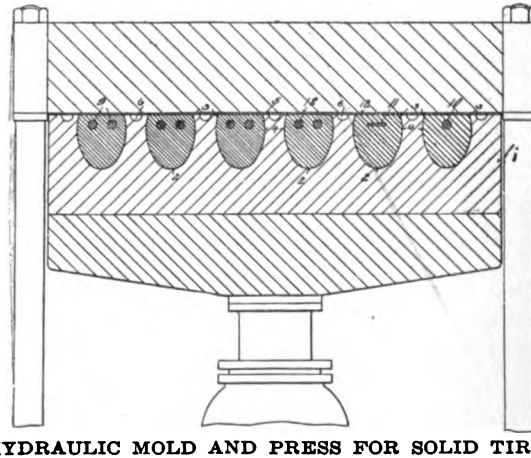
and Talbot at the University of Berlin, during which time they had seen carriages made for the King of Prussia by Neuss, the royal coach builder, equipped with rubber tires. The important New York carriage firm of Brewster & Co., of which Mr. Britton became the head, acquired the American rights under the Carmont patents, and several rubber concerns made tires for them. The demand for the tires, however, was mainly



COMBINED MOLD AND PRESS FOR SOLID TIRES.



HYDRAULIC MOLD AND PRESS FOR SOLID TIRES.

for broughams and other vehicles heavier than hansoms, and principally on the recommendation of physicians. The New York streets were then less well fitted than those of London for the new type of tire, which many complained did not stay in position. It was found that a tire made of a compound suited to keeping it in place had less resilience, and *vice versa*. Besides—though this was not at first appreciated—a large

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percentage of the rubber body, being held in compression, was robbed of resilience, and after that portion of the tire projecting beyond the flanges wore off, nearly two-thirds of the rubber remained, entirely worthless as a tire.

The next practical advancement in the development of the solid tire was made in America, under the patent granted to Arthur W. Grant (later known as the Kelly-Springfield tire). This tire being seated in a rim channel with diverging sides, there was no loss of resilience from the compression of any part of the rubber. The channels were not necessarily so deep as in the Carmont type, and a larger percentage of the rubber was available for wear. The rubber body was held in place by means of longitudinal wires—two at first, and more as larger sizes were made—running through the tire, and forming circles of smaller circumference than the rim flanges. Another advantage was that, under the new system, rubber compounds could be used that afforded better wearing qualities.

The introduction of the Grant patent was followed by a largely extended use of solid rubber tires, developing a trade which led to great activity among inventors in developing other methods of retaining the tires in place, it being recognized that something different from compression in the channel was essential.

The "Victor" tire differed from the Grant patent in that the longitudinal wires were encased in leather to prevent their cutting the rubber. Later the makers of this tire developed a specially woven fabric for encasing the retaining wires. The same effect was sought by other makers in the use of a flat, longitudinal steel band, instead of two or more wires. In England, the Carmont tire was modified by the introduction of longitudinal wires, wrapped with small spiral wires (under the Burgess patent) for the protection of the rubber.

In the United States, the Grant patent gained such vogue as to lead to the organization of a company with $10,000,000 capital to control it. The popularity of the tire led to its manufacture by a number of firms without regard to the patent, and the mass of litigation which resulted has not yet been cleared away. As matters now stand, the Grant patent is valid in some of the circuit court jurisdictions and not valid in others, no decision having yet been rendered by the United States supreme court.

The next epoch-making patent was for the "Sidewire" tire, held in place by two endless retaining wires sprung over the edges of the channel, which engage the ends of embedded cross bars, thus holding the tire securely in the channel. This tire possesses all the advantages of the Grant tire, and is preferred by many by reason of being more easily applied, and being free from liability to wire cutting, especially when put

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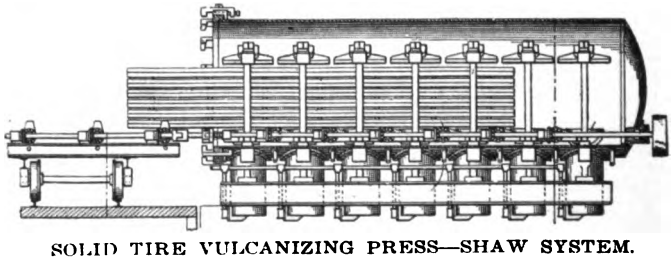
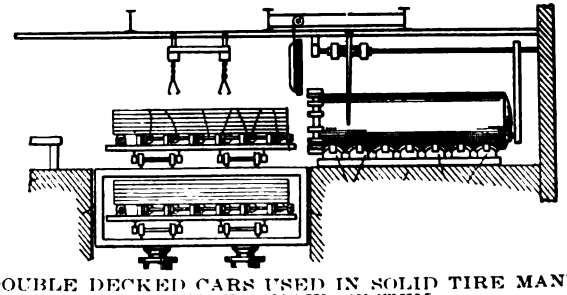
on without the longitudinal wires being of exactly the same length. The tire, also, is prevented from moving or creeping in the channel. It is known in America as the "Firestone" tire and described in Europe, where it has been widely introduced, as the "Byrider and Swinehart," from the names of the patentees.

Swinehart has more recently developed a new tire fastening, in the same field. This tire has a single longitudinal wire in its base, lying upon two sets of cross wires, each engaging one flange of the clincher rim.

Another form of sidewire tire is the "Republic," which is retained without the use of cross wires or holes in the rubber. The chief points in



SOLID TIRE VULCANIZING PRESS—SHAW SYSTEM.



DOUBLE DECKED CARS USED IN SOLID TIRE MANUFACTURE—SHAW SYSTEM.

the construction are the plates or bands passing underneath the tire and under the retaining wires at the side, thereby forming a clincher base.

The Motz tire, adapted to a rim of the clincher type, is held on without side wires. Embedded within the rubber is a row of parallel cross wires, lying slantwise across the rim, but too long to slip down into the clincher bed. In applying, the head is hooked under one clinch, and then the tire is bent back upon itself sharply, until two or three cross wires can be hooked under the other clinch. The whole tire can thus be put on, a portion at a time, so that the ends of the cross wires engage the clinches firmly. Another Motz tire, for heavy trucks, is held on by two parallel rows of cross wires, each pair crossing like a slender "X." Two "S"

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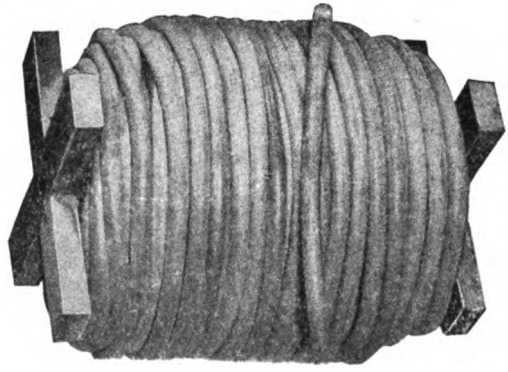
hooks go with each pair of cross stays, one end of each wire engaging the upper end of the "S," while the other end of the wire locks under the opposite clinch. The lower end of each "S" hook grips the clincher.

The chief difficulty with solid tires mechanically fastened by wires or steel tapes has been located at the splice, to make which the rubber has to be compressed. The result is that there is too much rubber for a given perimeter; the wires loosen or stretch, the rubber pushes away from the rim at the splice, the wires cut out, and the tire creeps. At least, these troubles may develop in case the tire is not applied perfectly. To avoid them, the "endless" type of solid tire has been designed—a tire vulcanized to fit the exact dimension of the wheel, and having its perimeter absolutely fixed. It is applied by removing a detachable flange of the rim, which, when replaced, is secured by means of bolts through the felloe. Two endless



REEL HOLDING 500 FEET OF CARRIAGE TIRE STOCK.

tires are illustrated here—the Wheeler and the Turner. In the former there are no retaining wires, the tire being held by continuous projections from the two rim flanges, engaging grooves in the rubber. The Turner tire is provided with inside wires, and the base reinforced by fabric insertions. The merit of the latter feature is that, whereas in some other tires the retaining wires bear only upon the rubber immediately beneath it, the fabric insertion binds the rubber in a measure, so that the wires engage the whole mass.

This leads to a mention of the "Diamond" wire mesh base endless tire. This has a base made of much stiffer rubber than the tread, and in this base the wire mesh or woven wire is embedded, encircling the tire several times. Being made in one piece, the inner circumference of the tire is almost exactly equal to the face of the smooth steel rim, over which it must be forced by driving with a mallet. The flanges are then bolted

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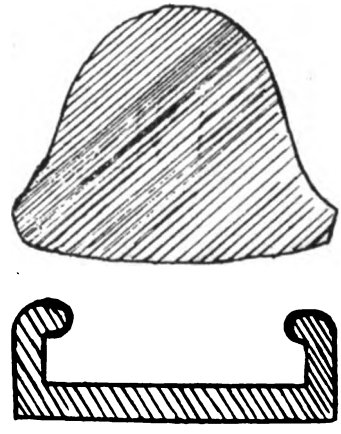
on, the tire being slightly wider than the rim, so that the stiff base is tightly clamped in the channel.

In the Kelly-Springfield endless tires use is made of "V" shaped retaining rings, bearing directly on the band of the wheel. These rings, each wrapped spirally with canvas, to which the rubber vulcanizes, thus giving a hold completely round the ring, are inserted in the base of the rubber. When the side compression is fully taken up by the cross bolt through the felloe, the tire becomes almost a part of the wheel, being dovetailed to it.

The "twin" form of solid tire, first introduced in England, has made much headway in Europe, and in America as well, especially for use on heavy vehicles. It is applicable to any of the types of solid tire made, all



BRITISH TIRE (CARMONT'S PATENT).

of which appear to reach their maximum of efficiency at a certain width. The limit is not rigid, of course, but in widths above say 5 inches, the strain of stopping, starting, and side roll cannot be distributed as it should be, through the whole breadth and thickness of the tire. The twin tires give less suction, have less road contact, give sufficient traction or road grip, and lessen the liability to skidding.

The Hall sectional tire has a tread surface composed of a number of projections from a rubber strip, kept in place on the rim by a steel tire holder. The base strip, with its projections, can be molded in as many sections as desired. The vibration with the use of such a tire is claimed to be less, for with the turning of the wheel each section acts separately. Then it is less liable to throw mud; when the rubber sections are in contact with the ground they are expanded, reducing the size of the inter-

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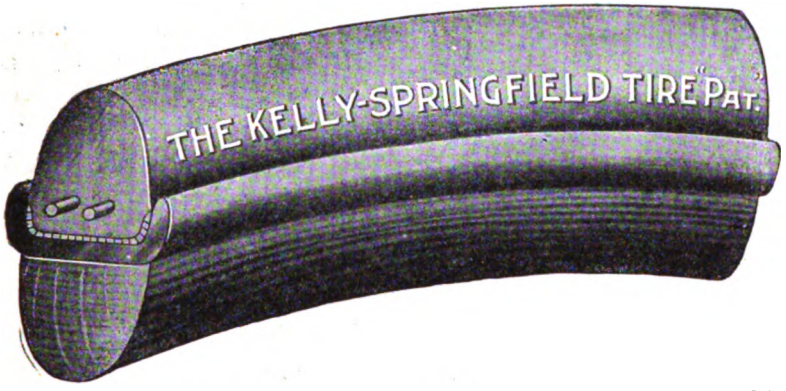
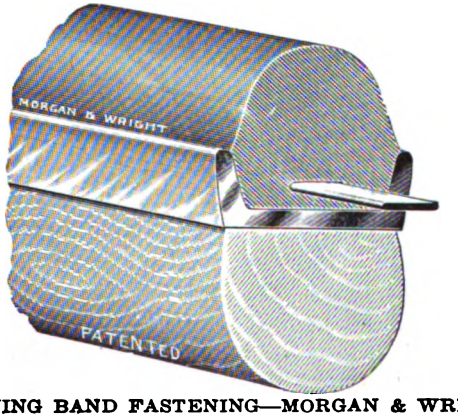
mediate spaces, and when relieved of the weight of the vehicle the sections contract, release themselves from the mud, and the suction is broken. A special advantage is that, if a section becomes injured, it may be replaced without disturbing the remainder of the tire.



AMERICAN TIRE (GRANT'S PATENT—KELLY-SPRINGFIELD TIRE).

Mr. George H. Hood, a rubber manufacturer successful in many lines, at one time produced solid rubber tires attached to a steel rim by the same method as that employed in the manufacture of rubber wringer rolls—covering the steel with a copper solution and vulcanizing the rubber to the surface thus formed. It was claimed that the rubber treated in this



RETAINING BAND FASTENING—MORGAN & WRIGHT.

way could not be torn from the steel by force, but that, if forced, the rubber would tear itself instead of leaving the steel. Not only was there no danger of such tires pulling out, but none of the elastic property of the tire was taken away by compression of part of the rubber to attach it to

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the wheel. This, so far as used, was applied chiefly in ⅞ inch width to light open buggies and traps.

As early as 1856 solid rubber tires were made by the Boston Belting Co., being designed by two mechanics, George Souther and George H. Miller. The first tires made were so soft that they used to fly out of the channel when driven fast, and they had another set made, which proved more successful; but the inventors are said to have been deterred from taking out a patent, because the police authorities warned them that the running of a vehicle so equipped was a "nuisance." The tire channel was about ⅜ inch deep on the outside. The rubber tire was about ⅞ inch deep in thickness and made almost square. The tire was made "snug" and "sprung on" with a rope.

VICTOR TIRE WITH RETAINING WIRES "INSULATED."

Except as stated, the various types of tires described in the preceding pages were of American origin, and the tires used in the United States today were for the most part first made under domestic patents. Besides, some of these tires have gained considerable vogue abroad, especially the Grant patent—known in Europe as the Kelly tire—and the "B & S" (Byrider and Swinehart). Inventors in Great Britain and on the Continent, however, have not been idle in this field, and many ingenious devices have been patented for retaining solid tires in place on carriage wheel rims.

Solid tires for bicycles were the subject of British patents in 1874, if not earlier, most of the rubber houses entering this trade before Dunlop patented a pneumatic tire, and when, later, a demand existed for solid carriage tires, the rubber people were in a position to make them. Thus far, however, the solid tires used in England have been and are mainly of the types already described. Leading manufacturers continue to list solid tires of the rim compression type—*i. e.*, without retaining wires of any

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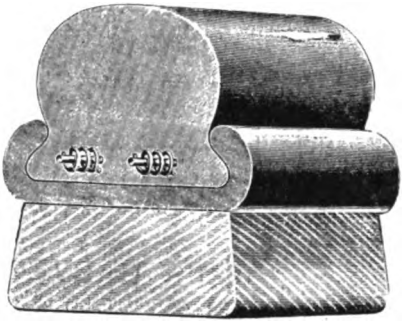
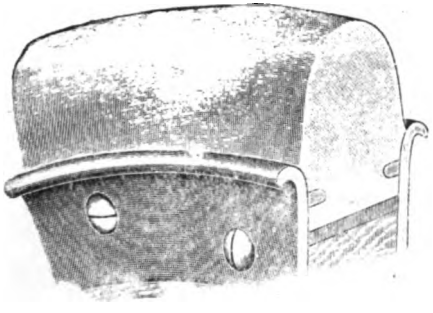
kind—but mainly for the lightest vehicles. In addition to the other rims mentioned, they are made to fit the clincher rim, made famous by the North British Rubber Co.

The same company make the "Clincher Grid" motor 'bus tire, in which the "grid" is of steel, made in sections, that bolt on through the

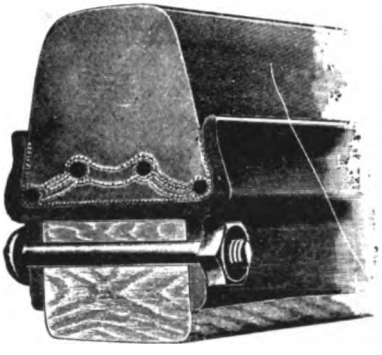


CARMONT SPRING WIRE FASTENING.

felloe, the rubber being vulcanized through the interstices of the grid. The especial advantage is the firmness with which the section blocks are held by vertical bolts, screwed into nuts cast with the steel grid. The block arrangement also serves to prevent the excessive heating of the rubber, to which endless tires are liable. This tire is also made with the blocks bolted on in two parallel rows, with the center of each block



WHEELER ENDLESS TIRE.



TURNER ENDLESS TIRE.

opposite the space between the two blocks in the other row. This arrangement prevents sideslip, and without such precaution a motor 'bus would be nearly unmanageable on some of the greasy, slimy, London streets.

Metzeler & Co., in Germany, make a solid rubber tire, the base of which, of hard rubber (vulcanite), is molded on and vulcanized to a steel

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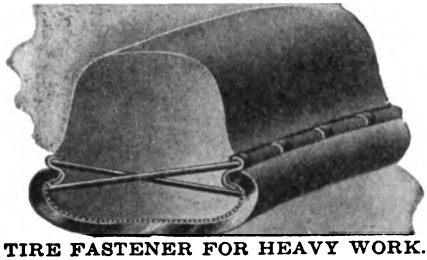
rim, the attachment being strengthened by a series of dovetails. This rim slips over the steel rim fastened to the felloe, and is held in place by an ingenious arrangement of screws. The tread part of the tire, made of soft rubber, is vulcanized to the hard rubber base.

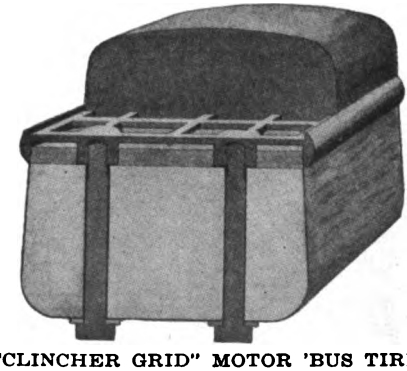
The "Duro" endless tire, another German product, is mounted directly upon cast steel wheels and held by flanges; but on wooden wheels a special steel rim is furnished, with a coiled steel wire, which engages



TIRE FASTENER FOR HEAVY WORK.

FIRESTONE TIRE.

the steel holding band vulcanized upon the tire. This holding band has several keystone shaped offsets, and is firmly embedded in the base of the tire. The tire is a fraction smaller than the rim, and has a countersink which fits a rising shoulder bar on the rim. In mounting, the rim is smeared with soft soap, and the tire forced on all at once by a pinch bar,



"CLINCHER GRID" MOTOR 'BUS TIRE.

slipping the wire under the tire into the holding band notches. When forced well on, the end of the wire is drawn tight and held by nuts under the rim.

The "Continental" solid tire illustrated here has embedded in it a rigid steel holding band, about which the rubber is vulcanized. It is further held in place by a flanged rim, between the sides of which it is compressed.

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PATENTS AND LITIGATION.

United States patent No. 554,675 was issued February 18, 1896, to Arthur W. Grant, for a rubber tired wheel for carriages. This provides for a wheel having a metallic rim with angularly projecting flanges to form a channel; a rubber tire fitting in said channel, and independent retaining wires passing entirely through the inner portion of the tire. Patent No. 555,480, for a device for putting on such rubber tires, was issued in the same year to Grant, assignor to the Rubber Tire Wheel Co., now embraced in the Consolidated Rubber Tire Co., organized primarily to exploit these inventions. A British patent was issued to Grant on this tire—No. 24,386 of 1895, of which Edwin Stuart Kelly is the registered owner. A French patent, No. 252,731, was issued April 10, 1896.

The Rubber Tire Wheel Co. brought suit for infringement of the Grant patent against The Columbia Pneumatic Wagon Wheel Co., in the United States circuit court in New York. The defendant made the point that each of the elements in the Grant tire had been so thoroughly anticipated by prior patents that their combination was not patentable. Reference was made (1) to the channel, (2) the solid rubber strip or band, and (3) the retaining wires. In a lengthy decision, reviewing the whole state of the art, Judge Thomas (December 27, 1898) held that Grant, by his combination of these elements, had produced a novel article, of a practical character, and therefore patentable.

The Rubber Tire Wheel Co. brought suit also against The Goodyear Tire and Rubber Co., in the United States circuit court at Toledo. Here the defense was threefold: (1) The want of patentability; (2) that the decree of 1898 was collusively obtained; and (3) that the tire made by the defendant was covered by the Joseph A. Burroughs's patent. Judge Wing (in 1901) decided that no evidence had been produced that the New York decision was the result of collusion, and he agreed with Judge Thomas as to the patentability of Grant's invention. As to the third point, he decided that the defendant's tire differed from the Grant tire only in that "there is a thin excrescence of rubber," between the solid rubber body and the rim, "which performs no function whatever."

The latter case was appealed to the United States circuit court of appeals at Cincinnati, where a decision was rendered May 6, 1902, declaring that "the mere bringing together of old parts and allowing each to work out its own old effort without producing some new machine or product is not invention." Again, the decision reads: "Believing the patent to be void for want of patentable novelty, we need not consider

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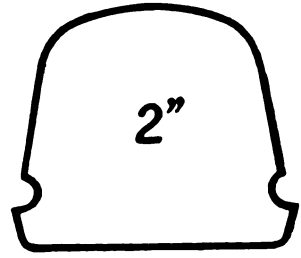
any question of infringement." This decision rendered the patent invalid in the states of Ohio, Michigan, Kentucky, and Tennessee.

In the action of The Consolidated Rubber Tire Co. *et al.* against The Finley Rubber Tire Co., in the United States circuit court at Atlanta, a decision sustaining the Grant patent had already been written by Judge Newman when he received notice of the decision above mentioned as having been handed down at Cincinnati. He was of the opinion, however, that his court should not be controlled by the voice of a circuit court of appeals of another circuit, and his judgment as to patentability went on record.



SECTIONAL VIEW OF MOTOR TIRE FOR SIDE WIRES.

SECTION SHOWING TIRE, SIDE WIRES, AND CROSS WIRES EMBEDDED IN THE RUBBER.

The following further information regarding the Grant patent is copied from a legal record: "The patent was also declared valid in the circuit court of appeals of the republic of France, sitting at Paris (1902). There is also an infringement suit now pending in the southern district of New York, brought to stop infringement, and also for the purpose of obtaining either an agreement in the various circuits as to the validity or invalidity of the patent, or such disagreement among them as will take the question to the supreme court. That court denied *certiorari* to review the Ohio decision (of May, 1902). The circuit court of appeals of the

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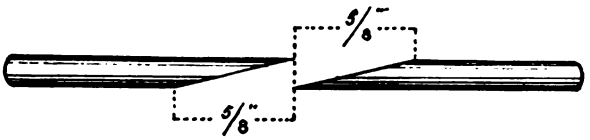

SIDE WIRE ENDS READY FOR BRAZING.

sixth circuit also held the patent invalid in Rubber Tire Wheel Co. *vs.* Victor Rubber Tire Co., following the Goodyear case."

The first infringement suit referred to in the above paragraph—The Consolidated Rubber Tire Co., *vs.* Firestone Tire and Rubber Co.—was decided in July, 1906, by Judge Platt, in favor of the plaintiff, reaffirming the decision by Judge Thomas in the same court in 1898, as to the patentability of Grant's invention.

The "Sidewire" tire is protected by United States patent No. 686,556, issued November 12, 1901, to James A. Swinehart and W. A. Byrider. The tires are made under license by three American companies, including The B. F. Goodrich Co., who also control the rights under the British patents. The other European patents are held by The Colonial Tire and Rubber Co., composed of the patentees, who have licensed manufacturers in France, Austria-Hungary, Germany, and Russia, these licenses embracing the sale of the tires in the rest of Europe.

ENGLISH CASES.

The suit of the Shrewsbury and Talbot Noiseless Tyre and Cab Co., Limited *vs.* Sterckx, was brought for the alleged infringement of Carmont's patent on the attachment of rubber tires to wheels. The defendant challenged the validity of the patent, on the ground of anticipation, mainly by a patent granted in 1862, to Alleyne and Roberts. Decision was given in favor of the plaintiffs, and confirmed on appeal in 1896. It was proved to the satisfaction of the court that prior to 1883, the date of the Carmont patent, the application of a rubber tire to the outside circumference of an iron tire, could not be made so as to be of commercial utility. There had been a limited use of rubber tires, but the cost, prior to 1883, of cutting out a groove in an iron tire by a lathe was as high as £20 for a set of four. But under Carmont's process of rolling wrought iron at welding heat, so as to form channel rims of trough section, the cost did not exceed £2 for a set of four tires. It was held that neither in the patent of Alleyne and Roberts nor in any other known publication had the process as developed by Carmont been described or suggested.

The suit of Sirdar Rubber Co., Limited, and Maclulich *vs.* Wallington, Weston & Co., for infringement of patent No. 11,686 of 1900, for a

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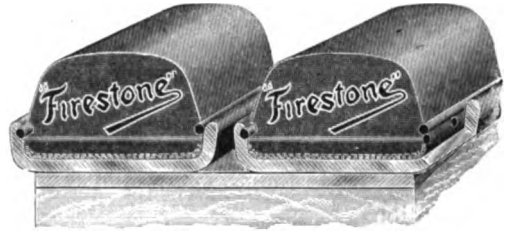
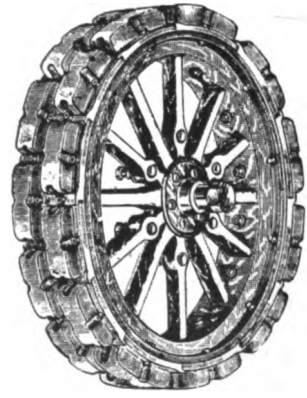
rim and solid rubber tire, resulted in a decision by Justice Swinfen-Eady, in 1905, that the patent was invalid. Under this patent, the rubber tire, of a shape corresponding to the interior of the rim, was to be inserted with ordinary pressure, and to be retained without being pinched or nipped by the edges of the flanges, or by the use of wires or bands.



FIRESTONE DUAL TIRE.

The aim of the patentee was to obtain a tire that should be held in place "in the rim, with additional security, under pressure"—that is, the vertical downward pressure of the vehicle, and the side pressure against the flanges, when in use. In the language of the court, the patentee thought "that he had secured an arrangement by which, the greater the force ordinarily tending to tear off the tire from the rim, the greater would



CLINCHER BLOCK TIRE—
NORTH BRITISH
RUBBER CO.

the force be (in his invention) tending to keep on the tire, that the total force holding the tire on would be increased in proportion to the external strains to which the tire was subjected. But it had been found in practice to be essential that, in order to keep within the rim, the rubber must be wider than the groove into which it is inserted, and that it must be forced

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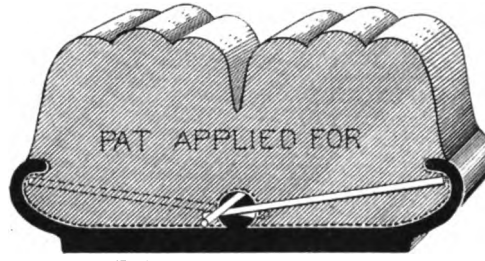
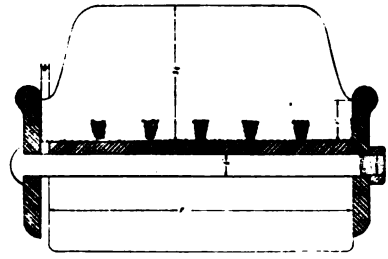
into the rim by machinery under very considerable pressure. If rubber of such increased size were forced into the plaintiff's rim, and if the base portion of the rubber were convex in shape, it would be a practical tire; otherwise it would creep, get hollow at the back, and leave the rim." The plaintiffs had met this point by saying that convexity and increased size and compression were common knowledge, and the patentee did not say that these should not be resorted to. But the specification itself was



SWINEHART TWIN TIRE.



RETAINING RING FASTENING—
CONSOLIDATED RUBBER
TIRE CO.

DIAMOND WIRE MESH BASE TWIN TIRE.

opposed to this view, and the plaintiffs in practice had departed from their own patent. The court saw no advantage in adhering to the exact section of tire and rim, and there was no difference in principle between the tire as really made by the plaintiffs and the tires long made under the patents of Challiner and others. Hence the objection of the defendants, that the invention as disclosed in the specification was not useful, was sustained, and the patent held to be invalid for want of novelty.

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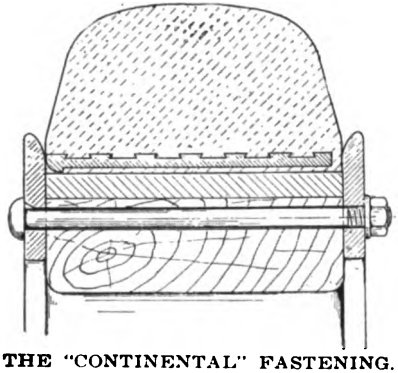
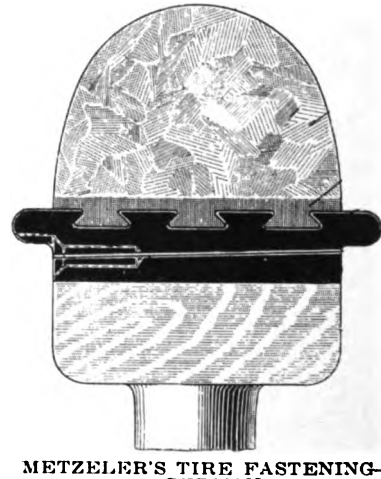
But assuming the patent to be valid, was there infringement? In the case before the court, the defendants, who were not makers of rims, had merely fitted one of the plaintiff's rims with a rubber tire. The plaintiff's real invention is a metal rim of a particular shape, and in the

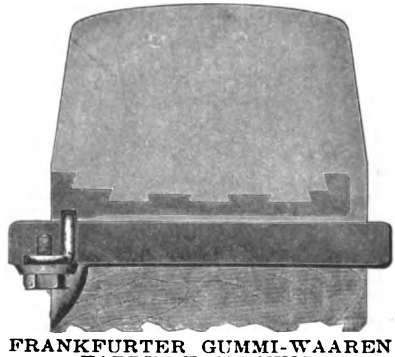


THE "CONTINENTAL" FASTENING.



METZELER'S TIRE FASTENING—GERMAN.

nature of things the rim is calculated to wear out a number of tires. Unless the purchaser is able to have new rubbers placed in the rim, he cannot obtain the use of the patented article for the fair period of its life. In this case there has not been a new article constructed, but a fair repair;



FRANKFURTER GUMMI-WAAREN FABRIK FASTENING.

the old metal rim, the distinguishing feature of the invention, being retained because essential and practically as good as new, and a fresh rubber put in to replace one worn out. In the opinion of the court there had been no infringement.

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In the court of appeal, in 1906, the decision quoted was affirmed, so far as it relates to the question of validity. The court did not express an opinion in regard to the matter of infringement.

Counsel for defendants, in summing up, had quoted the view expressed by Lord Justice Cozens-Hardy in Dunlop Pneumatic Tyre Co. *vs.* Moseley: "I certainly doubt, I do not say any more than that, whether the holder of a licensed tire may not replace a worn out cover without being guilty of an infringement of the patent." If the plaintiffs, said the counsel, wished to sell their tires on the condition that when the rubber was worn out the tire should be repaired by them, they might do so; that was a matter of contract.

SOLID TIRE COMBINATION.

The patent on solid tires granted to A. W. Grant in 1896 (No. 554,675) was assigned to The Rubber Tire Wheel Co., an Ohio corporation. Early in 1899 there was merged with this company The American Rubber Tire Co., of New York, known formerly as The Columbia Pneumatic Wagon Wheel Co., who had been defendants in a suit for infringement brought by The Rubber Tire Wheel Co. Shortly afterward two Chicago tire selling concerns were added to the combination—The Imperial Rubber Tire Co. and The Firestone Rubber Tire Co.—the combined businesses being acquired by The Consolidated Rubber Tire Co., incorporated in New Jersey in 1899 with $10,000,000 capital. Up to this time all the tires sold by these companies had been made for them under contract, but the Consolidated company established their own factory at Akron, Ohio. Some of the rubber factories formerly making tires for the company now began to make them for their own account, and other manufacturers entered the field, giving rise to a volume of patent litigation referred to already in this chapter.

There has existed at times a "pool" in the solid tire trade, one agreement, for a period of a year, having been dated October 10, 1903, and embracing eighteen rubber tire manufacturers in the United States. Several points were involved, including the quota which each company should manufacture in each month, and an undertaking to maintain a fixed scale of prices. The pool was managed by five commissioners.

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CHAPTER XXV.

LIFE OF SOLID TIRES.

THE tire troubles common to pneumatics are unknown to solid rubber tires. Still, they do have troubles, and they do wear out. It is just as impossible to foretell the life of a solid rubber tire as it is that of a pneumatic, and for practically the same reasons. Generally, the thing that happens to a solid tire is that it becomes loose, or breaks away from the rim. Or it may simply wear out. It is even impossible to tell in advance how long a solid tire will last without an accident to terminate its period of durability. One set of tires may last for six months; while another set made of the same compound, by the same men and methods, and run on a car giving as near as possible the same service, may be worn to the rims in a few weeks. There is not, never has been, and probably will never be, a satisfying explanation of this, but the fact remains.

Until recently, since the era of auxiliary treading began, a tire that had become unserviceable through the legitimate wearing away of the rubber on the road surface was discarded. What was left of the rubber was consigned to the scrap heap and a new tire substituted.

It is pertinent to call attention to the distinction between retreading and auxiliary treading. Retreading consists of the application of a new tread of rubber in place of the old one which has been worn off or stripped off at the factory or repair shops. The tire thus treated becomes in effect a new one. Auxiliary treading means the application of a tread of some foreign material over the original tread, keeping the original practically intact and employing the auxiliary tread more as a protector than as a part of the tire itself. While some may regard the distinction as trivial, it really is highly important. Retreading solid tires has never been popular. The operation has been declared impracticable by some of the American manufacturers, while others object to it on the ground of its not being economical. It costs about one-third of the original price to retread a tire, and the life of the tire is prolonged about one-third. So the owner of the car has lost the labor and time involved in sending the tire to the repair shop and waiting for its return without gaining anything. Worse than that, this loss and annoyance must be endured three times before he has got the mileage he could get from a new tire without appre-

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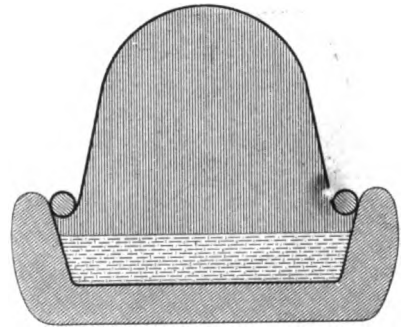
ciable loss of time and at the same monetary outlay. Another thing, the user of a retreaded tire never feels the confidence in it that he would in a new one.

The same rule that applies to one type of vehicles using solid tires applies with equal force to all. A motor truck, observation car, electric cab, or a light carriage may be fitted with a set of tires that are, apparently, exactly alike. Three of them may run until they are worn down to the rim, while the fourth may go to pieces in a week or two. There is no way to overcome this dissimilarity in the life of tires that logically should be the same, nor is there any way to account for it.

Some put the blame on the driver. Unjust or not as this may be, there is no doubt that some of the blame for lack of uniformity in the wear of tires may be charged up against the driver of the car. One may be careful and another may not. One may run a car for months without



McMAHON TIRE.

a mishap and his tires will last until they are worn, not racked. Another, though even more skillful, may through carelessness destroy the tires of his car in a few weeks, or even in a few days. A dash over a rough place, too sharp a turn around a corner, a turn of the steering wheels before his engine is in operation, a bump against an elevated road pillar, a sharp spurt across car tracks, and the mischief is done. A tire is wrenched loose or torn from its fastenings and the wheel is booked for the repair shop.

The fact that the chauffeur is an expert only tends to more firmly fix upon him the responsibility for the mishap. Nor does the knowledge that the expense and annoyance could have been easily avoided make the owner feel more like bearing the burden of cost.

Improper loading causes a very large percentage of the ills that befall solid tires. That is a broad statement and applies only to trucks and the heavier types of commercial vehicles. It is said that fully nine-

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tenths of the loosened tires become so because cars they are used on are improperly loaded. The strain on the tires of one of those heavy vehicles, some of which weigh 5 or 6 tons, is tremendous. Of course, this is greatly accentuated when a load of several additional tons is put upon them. The load is almost sure to be topheavy, and the result of a sharp turn or passage over a bit of rough roadway is apt to be disastrous to the tires, and neither the tires nor the maker can be justly blamed when there is a mishap under such circumstances.

In a few isolated instances tires have been sold with a guarantee of 6,000 miles, but for obvious reasons the average manufacturer refuses to give a guarantee of any kind beyond the general one covering good material and workmanship. It is regarded as a highly satisfactory service where a tire used on a big car runs 3000 miles without a mishap. On the lighter cars a run of 4000 miles is expected.

WHITMAN & BARNES TIRE.

The life of tires is sometimes lengthened by interchanging them. When the rear tires, upon which by far the heavier part of the wear falls, become worn, they are put on the front wheels, where they will sometimes run for many weeks longer than would have been possible had they been kept on the rear wheels. If a tire shows signs of weakness, it should be sent at once to the repair shop, or discarded entirely.

Manufacturers declare that a mileage guarantee, especially one for 6000 miles, is not feasible, since it would throw upon the maker all responsibility for overloading, unskilled and reckless chauffeurs, and accidents. It would seem that the point is well taken. Until absolute uniformity can be attained in the making, application, and use of tires, it would be sheer nonsense for any maker to give, or for any user to demand, a guarantee that a certain tire will run a given number of miles without accident or mishap.

There is no doubt that the hardest test that can be put upon rubber tires is in their application to fire apparatus. The vehicles are enormously heavy and they must be driven at the highest attainable speed over all

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kinds of pavements. Quick turning of corners, swerving aside to avoid obstacles, and running at a terrific pace over car tracks and rough places are every day happenings. The driver can give no thought to his tires when on the way to a fire. Under such conditions it would be natural and reasonable to expect the life of the tires on fire apparatus to be short. The contrary is the fact, however. It is surprising to learn that the tires on these great fire fighting machines endure, and in many instances without repair, for from one to two years. Obviously, it is impossible to calculate how many miles such a tire has been run, but the exactions put upon it must have been much greater than would have been demanded of it in a mileage anywhere else than 10,000 in ordinary use.

A number of manufacturers are turning out large quantities of "twin" tires, which are simply two solid rubber tires set side by side on the same rim. This type is fast gaining popularity for use on heavy trucks and the larger of the observation automobiles. They very seldom have anything happen to them that would necessitate sending them to the repair shop, so the item of "expense for repairs" does not figure largely on the books of the owner. They give better traction and have much greater resilience than one tire as wide as the two combined, while the cost is about the same.

SECTIONAL TIRES.

Several styles of sectional tires are in use, though, while having much to recommend them, they have not gained a strong foothold. The commonest type consists of a series of rectangular blocks of rubber set in a metal retainer which holds them in place on the wheel. Each of the blocks has a flange on each side which enables the retainer to get a firm grip on it. The tires are made in widths of 4 inches and upwards and are designed especially to meet the requirements of the users of heavy commercial cars.

Repairs are quickly and easily made, with the cost of the operation reduced to a low minimum. The retainer is loosened up, a new block is put in place of the damaged one, the retainer tightened again, and the job is finished. The cost is very slight.

There are other kinds of sectional tires that have some vogue, but they differ in detail rather than in principle. The method of repairing them is substantially the same except that the segments are held in position by different methods. One objection raised against this type of tire is that when repaired it is uneven on the surface and so causes the car to jolt. This is due to the wearing down of the general surface of the tire so that when the new section is put in position it extends beyond its

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neighbors on either side. The objection is soon overcome, so it is not to be considered too seriously.

The use of rubber tires for trucks and other heavy traffic is a curious instance of the divergence of theory and practice, though the divergence is not in the expected direction. Nearly all critics and general writers on this subject have insisted that rubber tires are an anomaly on a heavy freight truck, pointing out that a rubber tire is a luxury for passenger traffic, that the things will wear out in a little while, that the speed of such vehicles is too low to need any vibration absorber, and that the supposed necessity of rubber tires to secure the proper traction or road grip is a pure superstition. Thus the rubber truck tire is condemned from every point; yet it is a fact that the designers of these wagons, especially in America, very persistently stick to these tires, and the business has grown amazingly in the very face of the expert condemnation. The experts claim that if the slight friction between a smooth steel

SWINEHART CLINCHER TIRE.

tire and a smooth steel rail is enough to pull a whole freight train, the greater friction between a steel tire and a stone road ought to be able to pull a wagon. They claim that as cogs were once wrongly thought to be necessary on railroads, so are rubber tires now wrongly thought necessary for business vehicles.

In spite of all this expert opinion, the business man, who cares only for results, goes on using rubber tires, especially for city traffic. There may have been a time when he did this for advertisement; but that day is gone, and one will hardly say that the close fisted business man will spend his money on rubber tires for the comfort of the dear public. He spends this money simply because it saves more money.

The solid rubber tire has always run ahead of the pneumatic, and will probably continue to do so. The pneumatic is continually creeping up behind, but only to find that the solid has found new uses. The ambition of the solid tire makers now extends not only to the heaviest

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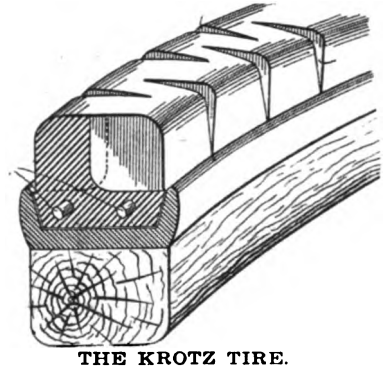
road wagons, but even to the railroad trains, which several inventors are planning to have shod with rubber.

When we consider the different reasons why rubber tires are profitable on business automobiles, the most important is undoubtedly that of traction. The driving effort of the motor must be delivered to the road through the tires, and unless the tires get the proper hold upon the road the self propelled vehicle is a failure. Now, the business man who has put his thousands into commercial motor wagons is not going to lose all this capital for lack of a few hundreds invested in tires which will enable his motors to do their proper work; and experience has shown him that



THE KROTZ TIRE.

SECTIONAL TREAD TIRE.

rubber tires will do this best. The rubber tire pays for itself and more, and that satisfies him.

The second advantage in the rubber tire is the cushioning effect, and the consequent saving to the machinery and to the load. This cushion or vibration absorber is a valuable feature, though it alone might not justify the use of rubber, since springs will take this up to a great extent. Users of rubber tires claim, however, that it is the lateral shocks which are hardest upon both machinery and load, due to the wrenching strain of swaying from side to side. This swaying is said to be accentuated by springs; and as proof that a rubber tire will take up lateral shocks they point to the injurious effect of side strain upon the tires. It is certainly

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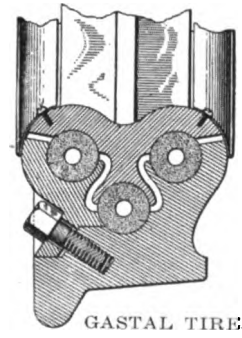
true that this wrenching is the hardest thing which a tire must stand, most solid tires tearing loose from their fastenings long before they are worn out.

A possible third advantage in the solid truck tire is the possibility of higher speeds than a rigid wheel would allow. To be sure, trucks are not designed for speed; but the fact that a motor truck, with rubber tires, can deliver more goods in proportion to the increase of speed is a very sound argument for the rubber. If pneumatics would allow more speed and consequently more goods delivered, the argument for this type of tire would be convincing, unless there were counterbalancing disadvantages, which seems to be the case.

In fitting a solid tire, it is important that the ratio of the size of tire to the load borne should be carefully studied. The general agreement on this point is that there should be one pound of rubber tire for each 30



GASTAL TIRE.

pounds of vehicle weight. This rule applies to tires made in one piece; and even then it is only approximate, for much depends upon the shape of the tire, the rubber compound, and on the degree of compression of the tire in the channel. More or less than this amount is thought to be uneconomical, from the point of cushioning effects, unless speeding is to be attempted. It must be remembered, however, that the strain upon the tire varies as the square of the speed. Thus, doubling the speed makes the treatment four times as severe, because the number and intensity of the shocks is doubled.

The accepted ratio of tire size to weight may be greatly reduced by division of the tire into several parts. The reason for this is that the rubber is given more room to expand, and the strain is thus better distributed. It is also possible to fasten the separate parts more firmly. It has been found that 4 or 5 inches is the practical limit to the width of a solid tire, owing to the impossibility of distributing through a larger tire the strain of stopping and starting and of side thrust. By building

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them of separate 3 or 4 inch widths, tires of any width may be obtained, which will do perfect work. For some reason this method has been found to give better traction, also, and it is very natural that they should skid less. It may happen, too, that one of these tires will suffer more than the rest, when it can be replaced without disturbing the others. Not only that, but it may happen that one of the twins or triplets may be severely gouged or cut in one place, while the rest of it is good. Consequently, the English are coming more and more to divide these twin tires into short sections, so that only the section which has been injured need be replaced. This type is called "elephant tread," "clincher grid," or block tire. The principle is excellent in many respects, but the method of fastening is rather distrusted by American tire makers, who prefer the twin tire principle, on account of the wire fastening.

Both the shape and rubber compound in solid tires have been practically standardized, though the methods of holding are various. Tire fastenings have always been very important, and most solid tire fastenings have been developed in the United States. It is believed by experts that a standard solid, when rightly proportioned to the load, would run 25,000 miles, were the legitimate wear the only thing to meet. In the great majority of cases, however, a tire will tear loose from its anchorage long before it is worn down to the channel. The various methods of fastening have been treated in another chapter.

Twin tires were at first connected in the base, and fastened as one tire; but experience has shown that it is best to make them entirely separate with separate channels or rims. Some neat devices have been worked out on this order, which are illustrated here. Separate fastenings are better both for holding and in replacement. Some of the endless types with inextensible bases, as the Turner and the Diamond, do not need separate fastenings, the tires being forced on the rim together, and held by one set of flanges.

Creeping has been found almost impossible to prevent in the case of heavy truck tires. Some solids have been made with blocks of wood or of hardened rubber embedded within them, these blocks being engaged by screws put through the rim from below. This has not worked well, however, because if the tire really starts to creep, these screws are torn out. Any creeping or looseness at the base makes the holding principle cut out in a little while. A method employed some years ago by the American Rubber Tire Co. consisted in having ribs in the channel bed, which fitted into corresponding grooves in the base of the tire.

Despite the difficulties found in holding on the standard shape of solid, many attempts are still made to pile large quantities of rubber on

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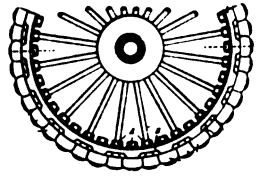
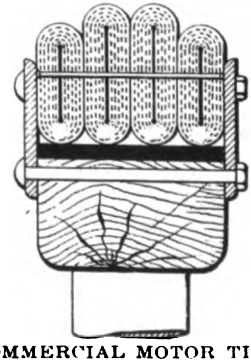
the tread, even to extending over the sides of the channel. That part which comes into contact with the flanges soon cuts away, and there is no use in building the tread up high, when the base will probably give way before the tread is worn half down. The most economical height is that which will wear just as long as the base is held to its moorings. The most economical width depends, as said, upon certain circumstances. Some claim that by using twin tires, a saving of 12 per cent. in width is effected. Others claim that for actual sustaining power, a 7 inch tire is equal to two 4 inch tires. A 7 inch tire is too wide, however, to do the best work, and it is almost certain that the same tire will last longer when divided.



HUBBARD TIRE.

WAITE TIRE.



COMMERCIAL MOTOR TIRE.

The tendency of nearly all heavy truck tires to chip or split has been considered by several inventors, and has been met, to some extent, by compounding considerable fibrous matter with the rubber. Persons of high authority claim that this method undoubtedly adds much to the life of the tire, without seriously interfering with its elasticity. The most recent development of this idea is that of the Commercial Motor Car Co., whose tires are made by wrapping many layers of canvas and rubber around a flat strip. Wide tires can be made by bolting together any number of these in the regulation channel. The elasticity is very greatly lessened, in this case, but the wearing qualities are improved, and skidding is almost prevented, though skidding is not usually a serious matter with slow moving trucks and other heavy vehicles.

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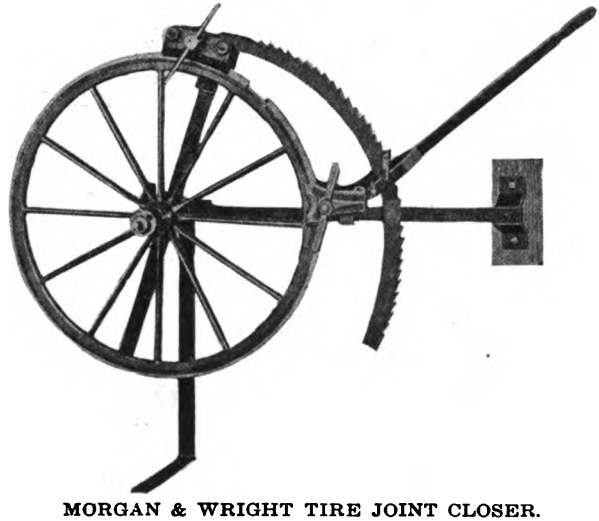
CHAPTER XXVI.

MACHINES FOR APPLYING SOLID TIRES.

THOUGH not so sensational as the pneumatic, the solid rubber tire has always been of greater commercial importance, and represents a greater total value. The pneumatic, for example, is applicable, with a few exceptions, only to pleasure vehicles. The solid serves a highly useful purpose in countless ways, and has ever been a



MORGAN & WRIGHT TIRE JOINT CLOSER.

competitor of the pneumatic on pleasure vehicles as well. Neither is there any assignable limit to the use of solid rubber tires; and when the rubber plantations shall have brought rubber within the reach of all, it is probable that the majority of wheels which run on hard roads will eventually be shod with rubber tires.

The solid tire has long been recognized as a sound commercial proposition. A large proportion of solids never really wear out, but tear loose from their fastenings and thus become worthless except as scrap. Could all tires be held on until quite worn out, this would be equivalent to a material reduction in price. For this reason, the method of holding has always been the vital point in the solid tire industry, and nearly all the patents issued for solid tires refer practically to rims and fastenings.

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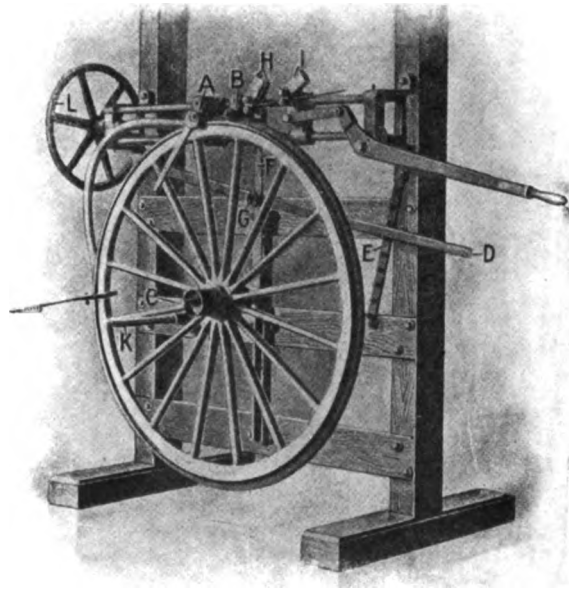
The application of a solid tire has been found impracticable with simple tools, and a great variety of machines have been designed to put them permanently in place. The business of affixing tires was once the jealously guarded secret of a few concerns; but as the art developed and spread to others, it has finally come within the reach of almost any repair shop or blacksmith, and there are now some dozens of companies who manufacture machines for this purpose.



HARTFORD RUBBER WORKS CO.'S SOLID TIRE MOUNTING MACHINE.

Before attempting to describe any of these machines and their operation, it would be best to see first just what is expected of them. Solids are generally held on by wires running inside, or outside circumferential or span wires under tension, or else by cross wires which engage a clincher rim, or by holding lugs or bolts. Most tires are held on by tension wires, and it is the application of these which calls for special machinery. All very simple, yet simple things are so easy to understand and so hard to create! How many remember the early attempts to fasten a solid rubber tire to the channel of a wheel, and keep it there? What

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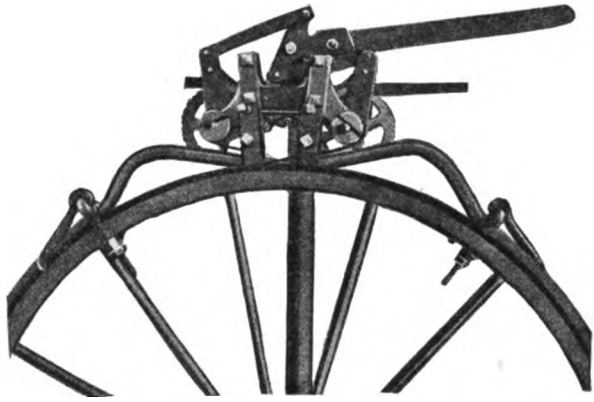
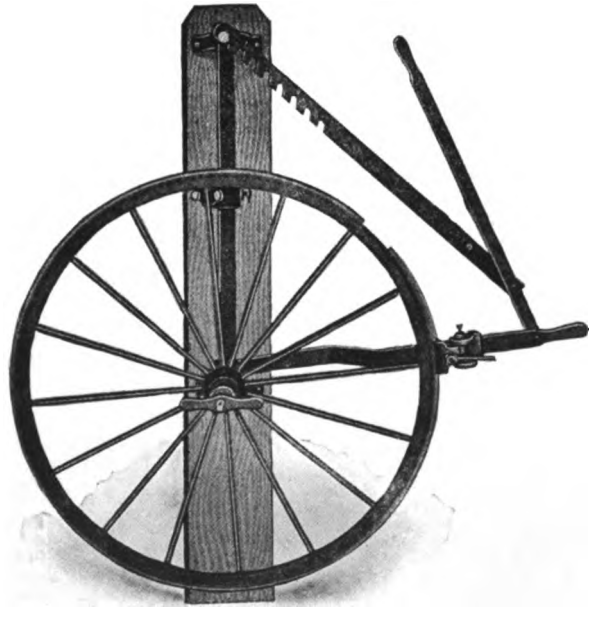


SWEET TIRE AND RUBBER CO.'S TIRE APPLYING MACHINE.



GOODYEAR TIRE AND RUBBER CO.'S TIRE JOINT CLOSING MACHINE.

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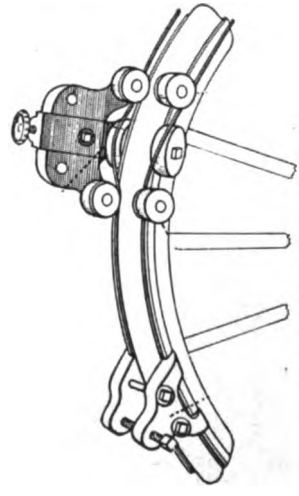
cumbersome special rims and intricate locking devices came at first! Who recalls the gutta-percha bands as a tire base that, applied warm, should shrink so as to hold the rubber in place—an idea that was scientifically correct but practically worthless. Hood's plan for coating the channel with blue vitriol and vulcanizing the tire in place was good, for the rubber stuck to the steel through the union of the sulphur and copper so tight that it could hardly be cut off, but wheelwrights, and carriage men generally, could not be equipped to apply tires in that way, and so on.

People were jolted over rough roads, carriages wore out before they should, and when the need was greatest the internal wire fastening was born. It was simply two or more holes running through the tire length-



FIRESTONE CONVERGING ROLLERS FOR LIFTING SIDE WIRES OVER THE RIM FLANGES.

wise, through which wires were threaded and their ends tied together (by brazing), holding the rubber firmly into the channel. Of course, there is a bit more to it than that—and given the tire, the holes, the wire, and a wheel, no man or men could quickly put them together. Hence, the tire applying machine was conceived. There are approximately 15 or 20 kinds that do the same work, and while they may look somewhat alike they are actually quite different. No one knows just how many of them there are in use as a whole, but of one type there are 5000, so the total number is presumably large.

Based upon the knowledge that a cut in stretched rubber yawns wide open, but in compressed rubber closes tight, every solid tire is compressed

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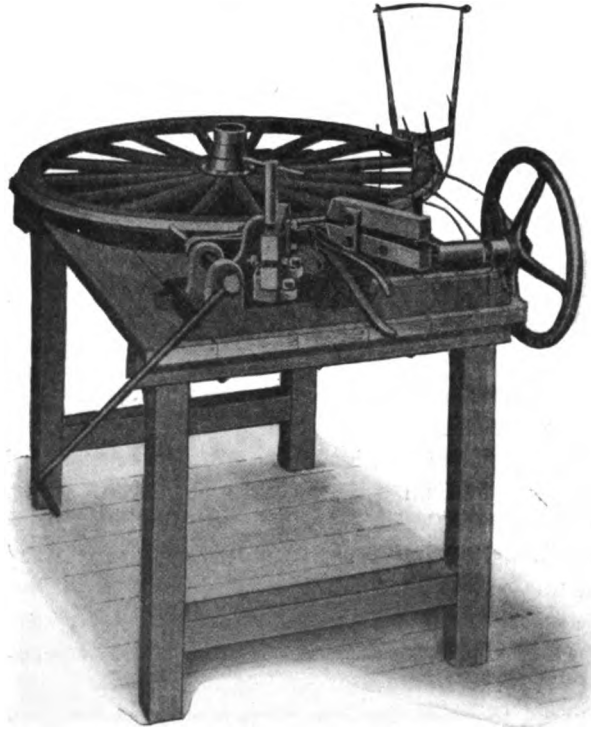
when it is put on, and is several inches longer than it needs to be to go around the wheel. Hence the tire applying machine must do, quickly and effectively, the following: Hold the wheel, hold tight the wire ends that project from the tire, push the rubber back as it draws the wires up, and hold that compression in some 18 inches of space. It must also bring the ends of the wires together evenly, hold them while they are scarfed, brazed together, finished smooth, and cooled off.

The wheel released, the work of the applying machine is finished. There still remains the compressed part of the rubber, however, to be attended to, which shows as a gap in the otherwise full channel. Certain tire applying machines have closing rollers, but most of that work is done by closing tongs, or closing machines. They are quite simple, being wide jawed grips hung on levers that bite the tire, and coax it along the channel (the 18 inch space has been previously slicked with channel paste) and finally butt the two ends together where good cement and compres-



CONSOLIDATED RUBBER TIRE CO.'S TIRE BRAZING MACHINE AND CLOSER.
[The devices for applying the tire, brazing the wires, and closing up, are assembled on one table.]

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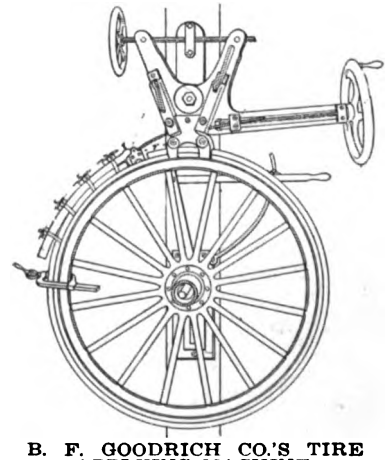
sion hold them so tight that no joint can be seen. In welding the wires together the majority use the regular brazing torch, but some of the large concerns use electric welders with good success. Since the business has grown so large there have appeared a variety of tools and fixtures of lesser importance, like the compression tongs, for example, but which merit no special description.

The side wire principle embodies a wide bottomed tire lying in a shallow channel, over whose walls accurately measured endless steel wires are forced, so that the tire is gripped evenly and tightly all the way around at once. Right here, however, let a word be put where it belongs. Many men cannot see how wire hoops, whose diameter is less than that of the channel flanges, can be forced over these same flanges without



B. F. GOODRICH CO.'S TIRE APPLYING MACHINE.

straining or stretching, and then literally grip the tire like hoops of steel. But it is as easy as sleeping. The wire is of rigidest steel, expressly designed against stretching. It is not the wire, but the rubber that yields, as one can see with half an eye. The wire being first caught over the flange at the bottom of the wheel, the upward strain causes it to bear directly upon the outstanding base of the rubber tire. There is a limit to the "yield" of this rubber; but if the circumference of the wire hoop has been accurately reckoned, the wires can just barely be forced over the flanges, when they will snap into the channel like garters and lie snugly upon their rubber bed all the way round at once.

It has occurred to some that the rubber will try to escape from the lusty embrace of the wires, when heavy side rolls come thick and fast; and so men have thrust cross spikes or slats through the base of the tire,

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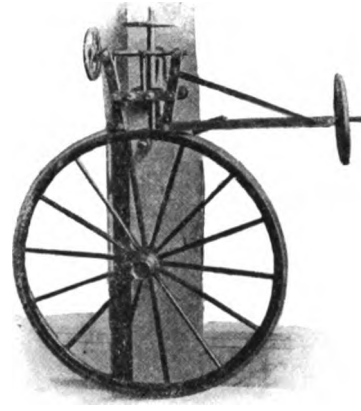
that the side wires might be sure of their grip. To make assurance doubly sure is praiseworthy, though there is such a thing as being good enough.

The machines used for putting on these wires are many, but mostly of one type. The wires are lifted upon rollers which converge at the rim, so that when these rollers are drawn circumferentially around the wheel by means of a powerful lever working on a ratchet arc, the wires must needs do as they are bid, willy or nilly.

The sidewire type is making its way rapidly in most countries in Europe, where it is known as the American tire. They must come to the sidewire type, however, as must all the world sooner or later; because it has real merit, and that which is good must triumph in the end.



INTERNATIONAL A. & V. TIRE CO.'S TIRE APPLYING MACHINE.

There are so many varieties of the sidewire type that the man with an idiosyncracy can probably get satisfaction from among the lot offered, and ordinary folks will find almost any one of them up to the mark.

Thus are the general principles briefly described. The details are many and interesting. The internal wire machines offer more variety, because of the more complicated process and the longer time they have had in which to develop. The construction of the machines depends, too, upon whether the several processes are to be performed by several machines or whether one machine is expected to do all the work. The small repair man wants the latter type, while the regular outfitter, who wants to rig numbers of wheels, finds it better to divide the processes among several machines.

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The lever and ratchet arc principle seems to be the most popular, since this allows the clearing of a wider brazing space than the screw principle, though the screw principle is very good in case of the larger tires, giving more compression power and allowing a more even strain upon the wires. With the ends of the wires brought together and held, it is simply a question of forcing back the rubber, which can be done in a variety of ways. After the ends of the wires are brazed together or welded by electricity, the rubber may be worked back until the ends meet, by simply striking slanting blows with a hammer. That was the way that it was first done; but this did not distribute the compression evenly, so the grooved roller was then used. This grooved wheel just fitted the tire, and by means of a lever it could be pressed hard against the rubber. By bringing pressure upon this roller and turning the wheel under it, the rubber was driven or crimped along with a sort of wave motion until the ends of the tire met at the point where the wires were brazed. This method was, of course, suited only for very light tires; so that most shops now prefer to use lever tongs, by which the tire is caught and drawn along.

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CHAPTER XXVII.

LEATHER, PAPER, AND WOODEN TIRES.

PERSONS who are familiar with pneumatic tires only as they see them on the street or in the shop windows are most likely to consider the rubber the essential feature; and, strange as it may seem, there are yet many people who know not of the very existence of a textile "fabric" within the tire. On the other hand, those who have had considerable experience with pneumatics are too apt to consider the fabric the essential feature of a tire. Neither of these classes realized, until lately, that neither rubber nor fabric is really essential.

The rapidly increasing use of leather as a tire material created some stir among tire makers, whose preconceived notions on the subject were completely upset by the appearance of a tire made of waterproof leather. Here was something that was concerned not at all with rubber compounds, proportionate thicknesses, tread cushions, armor plate, breaker strips, sand boils, stone bruises, separation of plies, tread wrenching, blowouts, and unequal tensions, and cared nothing for the vexed questions about Sea Island versus Egyptian cottons, thread fabrics, or square weaves, parallel threads and airless cords, rivet fabrics, thread chafing, bias cutting, wrapped treads, constrictive features, tangential strains, and the thousand and one parts and ailments of the ordinary rubber-and-fiber pneumatic.

It must be remembered, of course, that the leather tire is still in its infancy, and what will it be when it is still further waterproofed, made more lively, and shall have definitely abandoned the clincher principle in favor of the wired on fastening? Will it solve the knotty tire problem and entirely supersede the delicate, complicated, fabric-and-rubber tire?

The idea of making tires from leather is not new, certain Canadian firms having made pneumatic bicycle tires of leather ten years ago. The project seems to have failed, for some reason, but the idea was again taken up in Australia, where it has been tolerably successful. During the last two or three years there has been a great revival in the use of leather for tires, due to several important discoveries in rendering the material resistant to water. Unlike rubber, the effect of water upon ordinary leather is very injurious, hardening it so that it tends to crack, especially around the bead. Could it be rendered waterproof, so that it

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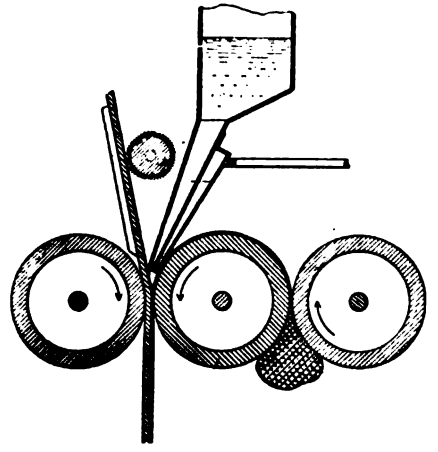
could preserve its softness, leather would certainly be a good tire material. The objection is often heard to leather tires that they are not resilient. A stiff leather tire is not resilient, but a tire of flexible leather is. A steel tire would be resilient, if the walls were pliant enough to bend, when running over obstacles. Tests made in California by the Anti-Rubber Tire Co. are said to indicate that their leather racing tires are actually faster than rubber tires, on account of the extra thinness of both walls and tread. In strength and resistance to punctures and road wear, leather is, of course, superior to rubber.

The most popular method of preparing raw hide for tire making is by the chrome process, in which salts of chromium seem to be used instead



MACHINE FOR COATING LEATHER WITH RUBBER.

of oak bark. The details of the process are not generally known, but the result is a leather having much of the softness and strength of raw hide, while being nearly waterproof. Various other chemicals and secret processes are used by the different leather tire makers, and the study being done in this direction will doubtless result in the discovery of a process which will render leather waterproof for all practical purposes. The Australians have succeeded in forcing rubber into the pores of ordinary tanned leather, and claim that the softness of the leather is indefinitely preserved thereby. This leather is used both for bicycle and automobile tires. Artificial leather is also made by combining rubber and shredded leather, thus being much cheaper than natural leather. This composite is used as tread strips on many rubber tires, in order to resist road wear and punctures. Consequently, the objection sometimes

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offered, that the world's supply of leather is insufficient for the use of it in tires, will be found to apply no more to leather than to rubber. By this method, artificial leather can be made of leather which has already been used for other purposes, leather scrap being reclaimed, much as rubber scrap is now utilized. Artificial leather is also waterproof; and though inferior to natural leather in tensile strength, it might well be used in connection with the latter, since it is nearly as resistant to road wear as is real leather. Tire leather might also be made of horsehide or from

SAMSON LEATHER TIRE.

the skin of pigs and sheep, if suitable methods could be found for curing these.

There are not very many firms, at present, which make tires wholly of leather, and the ones which do generally employ mechanical fastenings, instead of the clincher type. This is because of the difficulty of attaching a good and trustworthy clincher bead to leather tires; and the use of mechanical fastenings has undoubtedly retarded their introduction, on account of the present popularity of the clincher. Some of the California leather tire firms have adopted simple metal hooks, instead of the customary bead. The wired on fastening seems to be the best means of

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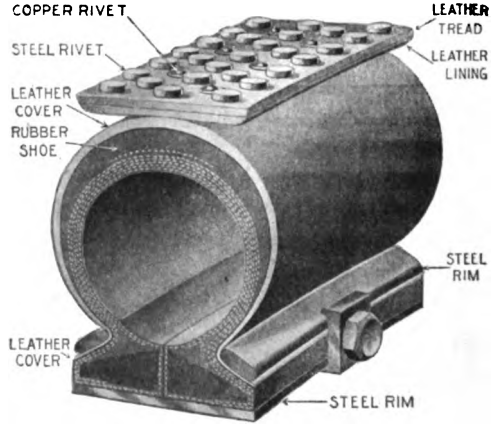
holding leather tires, now that detachable flanges have been so much improved.

Where leather tires are made of two or more thicknesses of leather, they have been found to chafe, unless the layers are cemented together by some material, preferably rubber.

The principal use of leather in tire making is in covers for ordinary rubber tires. Some firms, by vulcanizing the leather cover directly to the fabric, have saved the cost of this rubber and made a better tire as well. An all-leather tire will not rot, heats very little, and is proof against blowouts, sand boils, and the other various ills to which rubber-and-duck tires are subject. The only real objection to leather is its liability to



SECTION OF FISK TIRE LEATHERIZED
HEALY LEATHER TIRE.

harden and crack under the inevitable exposure to water, but modern chemistry is rapidly removing this objection.

Not only pneumatics but solid tires are now being made of leather. The solids are formed by stringing pieces of leather, cut to the desired shape, upon the regular holding wires. By this means, leather scraps can be utilized, it not being necessary to cut into the large hide.

PAPER TIRES.

The dominance of rubber in tire making has become so absolute, that many people may not even be aware that it ever has had or ever will have any serious rivals. As a matter of fact, rubber is a striking case of the survival of the fittest in the long run, having won its way into common favor by its considerable excellence in all the lines of elastic tire making.

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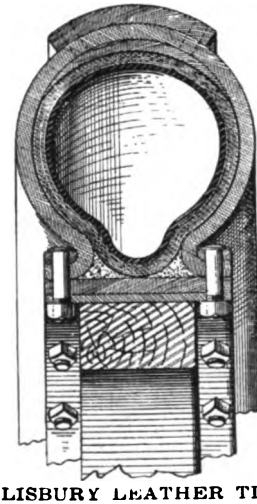
In the early days of tire making, when elasticity alone was specified, every conceivable elastic material was tried; but the great majority of these, while serving this purpose fairly well, were found wanting in other necessary qualities, such as durability under road wear. Rubber and leather were found to answer both these purposes, and several others very well indeed, but their cost was against them. Paper or wood pulp, while being very cheap, was found to be both elastic and durable to a considerable degree, besides being light and possessing fair tractive properties. For these reasons paper has always been in view for elastic wheels and tires. It suited the purposes of railway car wheels exactly; and since less traction was needed here, a steel tire put around the paper wheel prolonged its life almost indefinitely. Not only that, but the modern



SALISBURY LEATHER TIRE.

automobile truck has created an extensive market for paper wheels. These, used in some of the English cities, look something like car wheels, except that they are larger and do not have steel tires. In this case traction is more important than road wear, so that the tread as well as the wheel is of paper. Of course, this use of paper wheels is very recent, and has hardly gone beyond the experimental stage. The traction is almost perfect, and this is the important feature in self propelled traffic. The elasticity seems to be sufficient for heavy, low speed trucks; and though their wearing qualities have not been fully tried out, the wheels and tires seem to be holding up well.

Many persons are familiar with the use of paper in making solid tires, but few realize that it has several times been used in making

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cushion and pneumatic tires. Early in 1894 some American firms tried a number of experiments in making single tube tire covers of paper, these being stuffed with curled hair instead of air. Otherwise, these paper tires were like ordinary single tube rubber tires, and the walls were said to stand bending fairly well. The project was not successful, though the idea attracted much attention in Europe. During 1895 patents were granted in various European states for pneumatic tires to be made of paper, these being divided into several pneumatic compartments. The scheme failed completely, and seems never to have been tried since.

More recently several wheel makers have taken up the scheme of paper tires for automobiles. The present idea, said to be the invention of a Wisconsin man, consists in building up the tire in one piece on the wheel, by wrapping gummed paper about it to the desired thickness, and then bolting the channel flanges to the sides. The resilience may be added to by inserting a band or cushion of rubber between the rim and the paper tire.

WOODEN TIRES.

It is a simple proposition to explain that the original wheel of wood was a block sawed off the end of a round log; but this does not explain where the saw came from, and it violates the probabilities that wheels have existed longer than saws. It is sufficient for the purpose that some primitive communities still use wheels made wholly of wood, so that the idea can not well be called new, now that firms in various parts of the world are making motor truck wheels wholly of wood, or else with wooden tires.

The trouble about the wheel made of sections of logs is that the grain runs in concentric circles, with the fibers perpendicular to the plane of the wheel. This is the position in which the wear on a motor wheel would be most rapid, though the wheel might continue round in shape. Wheels cut out of a single plank, as made by children, soon wear to ellipses, because the wear is greater on the cross grain than on the end grain. It remained for our own industrial system to work out a wooden wheel in which the grain all runs radially, thus conducing to the maximum wear, at the same time preserving the roundness of the wheel.

Some time ago a famous English motor racer suggested that wooden tires would do as well as pneumatics on the Florida sands. Many thought that he was merely seeking notoriety, which the remark certainly earned him; but it is also probable that this chance statement suggested a train of thought resulting in the establishment of several factories for making wooden tires, both in the United States and Great Britain.

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Unlike most raw materials, wood is exceedingly variable in hardness and wearing qualities. Some varieties have little more elasticity than iron, while other kinds are so soft that they would not resist road wear. For some purposes, as very heavy motor trucks, moving at slow speed, it is possible to forego resilience, though traction is absolutely essential. Reports on the tractive qualities of wood tires do not exactly agree as to whether they are better in this respect than rubber, so that we may conclude that they are about equal. Even among users of rubber truck tires, it is a moot point whether traction or resilience is the more important quality; but the fact that iron tires are sometimes used in the summer instead of rubber, indicates that truckmen really attach most importance

STEVENS'S INDURATED FIBER TIRE.

to the tractive feature of rubber tires, for which purpose wood tires are equally good. As for the relative cheapness, rubber truck tires will cost about five times as much as the wooden ones. In other words, resilience, a secondary consideration, costs, including upkeep, about six times as much as traction, the primary consideration.

When wood tires were first used, it was pointed out that besides competing with rubber directly for tractive purposes, they could be used on trucks under loads that rubber would never hold up. This was true at the time; but through improvements in twinning and tripling rubber tires, it is now possible to make them bear any kind of truck load, without necessarily increasing the cost disproportionately. Wooden tires, therefore, have no special field of usefulness in which rubber does not compete.

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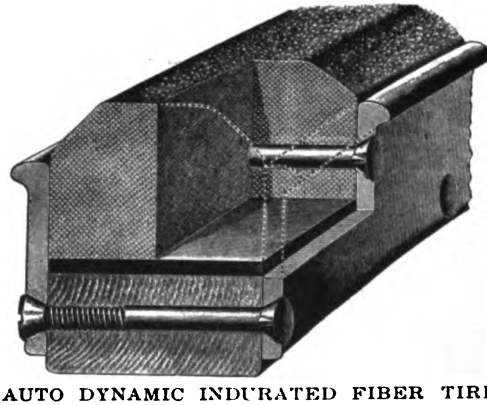
The plan on which most wooden tires are made and fitted is to drive wooden wedges into a rim channel made specially strong to resist lateral compression. In some cases these wedges reach clear to the hub, thus dispensing with the rim and making the whole wheel of wood. In such cases, a shoulder runs around the wheel where the rim would ordinarily be, iron bands being shrunk upon these shoulders to hold the wheel firm. This method increases the resilience of the wheel, deadening all sound and much of the vibration. It also has the merit of simplicity; but when the tread has worn down to the shoulder bands, it becomes necessary to make a new wheel. It is getting more common, now, to make the wheel, whether of wood or iron, with a steel rim, in which the wooden blocks may be replaced as often as necessary. With such rims, the whole tire may be renewed, or only such blocks as need attention. Even if the new



AUTO DYNAMIC INDURATED FIBER TIRE.

block stands slightly above the level of the rest of the tire, it will not be for long, because it will soon be "broomed over" to the level of the others. Indeed, it is better to have the new block stand up high, else the brooming will leave a flat spot on the wheel circumference.

Some wheels made so have a cushion or under tire of rubber for the wooden tire to rest upon, the rubber thus yielding resilience, while the wood stands the wear. This expedient has been very popular among the inventors, but the trade is rather in doubt about the feature, since the play in the combination, necessary to utilize the resilience of the rubber, soon ends in the breaking up of the wooden tire. If resilience is necessary, it would seem better to use a simple rubber tire, or else gain this quality within the wheel itself, as is done by many firms. The best type of wooden tire consists of blocks driven firmly into a channel, and then clamped with through bolts.

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These tire blocks are made of hard wood condensed still more by hydraulic pressure. This extreme hardness naturally decreases the traction, so that one or two lines of very soft wood are sometimes inlaid in the hard wooden tread. The soft wood picks up dust readily, and starts the process by which the whole surface of the tire finally contains embedded grit, like a wheel charged with diamond dust, so that road wear practically ceases. Sometimes thin steel wedges are driven in between the wooden blocks, though these are not necessary, if the tread grits over properly.

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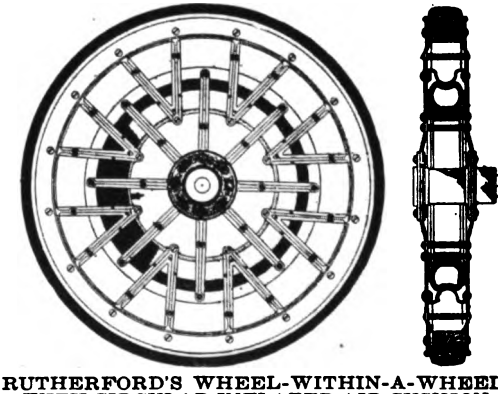
CHAPTER XXVIII.

SPRING WHEELS.

WHENEVER we consider the easy running of a vehicle, we must also consider the character of the road over which it runs. Vehicle and road are inseparably connected in thought. During the perfection of the automobile or locomotive in the early part of the last century, it was found that vibration was fatal to the efficiency of the



RUTHERFORD'S WHEEL-WITHIN-A-WHEEL, WITH CIRCULAR INFLATED AIR CUSHION CONNECTION—AMERICAN.

vehicle, aside from its effect on the passenger. Knowing the virtues of smooth roads, and not knowing about spring wheels, the whole attention of the engineers was concentrated upon road making, resulting in that most perfect of roads—the steel rail.

For a whole generation, this idea of road perfection occupied all minds, R. W. Thomson, of England, being about the only man who was thoroughly committed to the subject of wheel perfection. Thomson bent all his efforts to securing resilience within the tire, and his efforts foreshadowed practically all later developments in that line. He succeeded in interesting the rising generation to such an extent that they bent all their energies to perfecting the tire, rather than the roads over which they were to go.

The pneumatic tire was practically perfected in 1895; but while its springiness is all that could be wished for, taking up most of the vibra-

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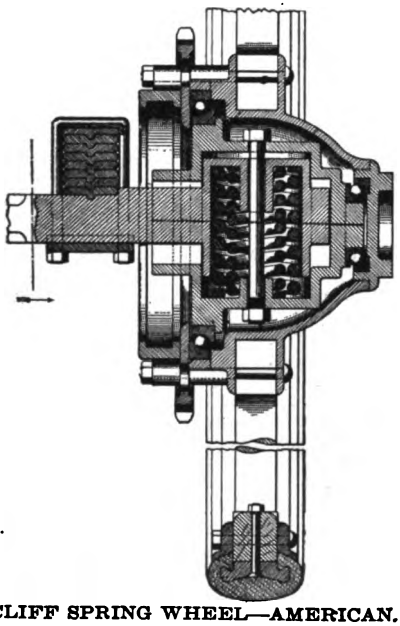
tion of the average road, it has very grave shortcomings. The consequence is that men have been thrown back upon the two ideas—road improvement and securing high resilience without the inconvenience of the pneumatic tire. It is probable that more attention has been given to road making within the last ten years than was given to the subject in all the ages preceding. This is very hopeful, being the natural solution of the light vehicle problem, just as the railroad solved the locomotive question. When the cause of vibration is largely removed, the solid rubber tire on a large rigid wheel can handle the situation well enough; and after all, this is really the standard among resilient wheels.



CLIFF SPRING WHEEL—AMERICAN.

Both historically and logically the subject of spring or cushion wheels includes the whole subject of elastic tires, since the resilient tire is only one application of the general resilient wheel idea. By definition, the resilient medium or member may be placed anywhere between the axle and the ground; and as a matter of fact, the resilient body has been and still is located in different places within the wheel, according to choice. For various reasons, however, it was very early and quite generally agreed that it was best to place the elastic body as near as possible to the ground, which was in the tire.

For many years, as said, the elastic tire idea completely overshadowed the elastic wheel idea, so that when attention was again drawn to the

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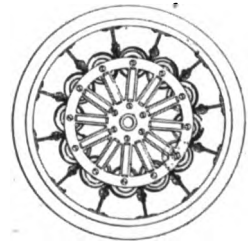
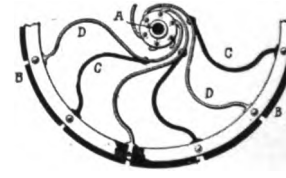
elastic wheel, the two ideas were considered essentially different. Nowadays, when we speak of a spring wheel, we mean one in which the resilient portion lies between the tire and the axle. Even then we must not press the definition too closely, or we may find ourselves driven to include certain types of puncture proof pneumatic tires, under the head of spring wheels, since the elastic portion really lies within the rim, instead of in the tire proper.

Holding to our definition, we would classify the various types of spring wheel according to the location as well as the nature of the elastic substance. According to location, we would consider elastic rims, elastic spokes, and elastic hubs, as well as a certain intermediate type, in which the elastic member is interposed, about midway between the hub and the

HARMON'S BENT STEEL SPOKE—AMERICAN.



HARTFORD'S FLAT SPIRAL TENSION —AMERICAN.



CHILD'S DOUBLE "S" SPOKE.

rim. According to the nature of the resilient material, we would divide elastic wheels into the air cushion, rubber buffer, and metal spring types.

If we consider number, form, and the public attention, we may say that the spring wheel industry has practically grown up within a year. Like all other ideas, it is not wholly new; but its real evolution covers months, rather than years. Even now the number of types has grown into dozens, if not scores, and public spring wheel contests have already been held in England, France, and Belgium.

Following the idea of Thomson, several Britishers, during the seventies, attempted to locate the source of resilience within the body of the wheel. Woodford Pilkington, of London, made a wheel with telescoping spokes, the plunger bearing upon coiled springs. This principle of the telescoping spoke is still popular among inventors, the plunger or piston sometimes bearing upon compressed air instead of springs. MacLaren was working at the same time upon the flat spring steel spoke, and his wheel, patented in 1881, well represents this principle, modifications of which he afterwards patented.

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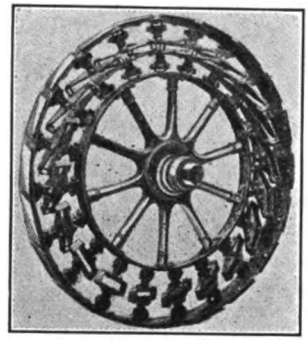
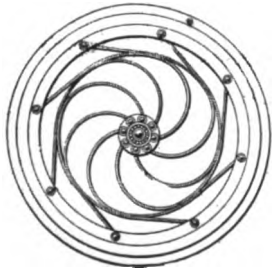
In 1884, Thomas Aveling patented a wheel, but his invention seems never to have been followed. The rim was hollow, allowing free play to the rigid spokes. Inside the hollow rim were coiled springs fixed tangentially to the spoke ends. Unlike all other spring wheels, this threw the spring suspension upon the horizontal instead of the vertical spokes.



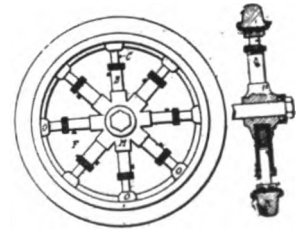
DR. BORCHERS'S DOUBLE RIM COMPENSATING-SPRING SUSPENSION.

In 1885, one Alfred Craig made a wheel in which he boldly incorporated the three main types of spring. It had three spokes, one bearing upon a thick rubber buffer, the second bearing a spiral, while the third spoke played against an ordinary laminated spring.

About this time the public attention became concentrated upon the



McKEE'S BENT STEEL SPOKE —AMERICAN.



COSMOS TELESCOPING SPOKE—AMERICAN.

rubber tire, to the neglect of the spring wheel proper, the existence and possibility of which was forgotten for some twenty years.

It may be stretching a point to include under elastic wheels, the light, well dished buggy wheel, with its slender, springy, hickory spokes; but why not? Experts are well aware of the very considerable resilience in

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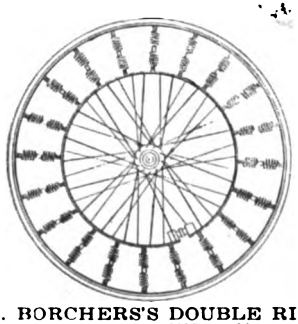
such a wheel. Moreover, this construction, while increasing its springiness, adds greatly to the strength of the wheel, which cannot be said of most types of resilient wheels. It is a wonder that this principle has not been used in automobile wheels, taking, for instance, flat spring steel for spokes, and as much dish as is required. By this means, side strain, and buckling, the fatal defect in many spring wheels, would be avoided by the same principle which secures elasticity.

The shortcomings and vexations of the pneumatic could be dealt with, after a fashion, so long as they were confined to bicycles. Nevertheless, the Spring Hub Bicycle Manufacturing Co., of Des Moines, Iowa, did a fair business in 1900 with their bicycle spring wheels. With the coming of the automobile, the limitations of the pneumatic became a matter of serious import. Gradually the dread of punctures and other accidents peculiar to the pneumatic has grown in the public mind, until it would



DR. BORCHERS'S DOUBLE RIM SPIRAL SUSPENSION—GERMAN.

FERRAND'S TELESCOPING SPOKE—AMERICAN.

be impossible to estimate the deterrent effect of this great handicap upon motoring. The consequence is that present day thought runs toward puncture proof devices and spring wheels, with the idea of securing the very great advantage of the pneumatic without its drawbacks.

As might be expected, the first and strongest call for spring wheels came from the makers of commercial automobiles. In this case the pneumatic was, of course, out of the question, and yet it was very desirable to lessen vibration and jolting. The first move was made in England, following the meeting of the Self Propelled Traffic Association at Liverpool, in 1898. Solid tires were rapidly improved, and several types of wheel were made, in which solid rubber cushions were interposed between the rim and hub or under the steel or wooden tires. Then Robinson made his "Empire" wheel, with compensating springs, and Clifford Halle rapidly came to represent the spring wheel idea in Great Britain. Thomas Gare worked on the idea of securing resilience by using a great number of

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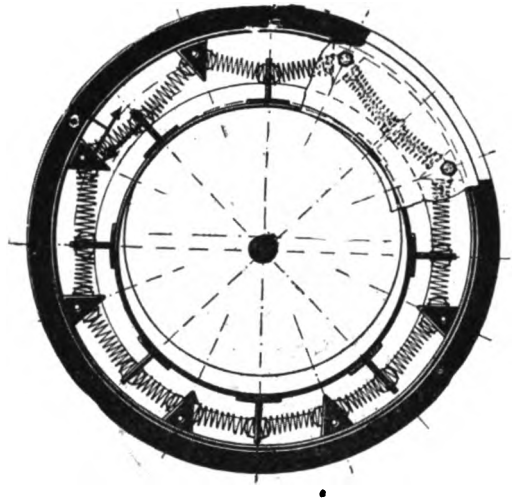
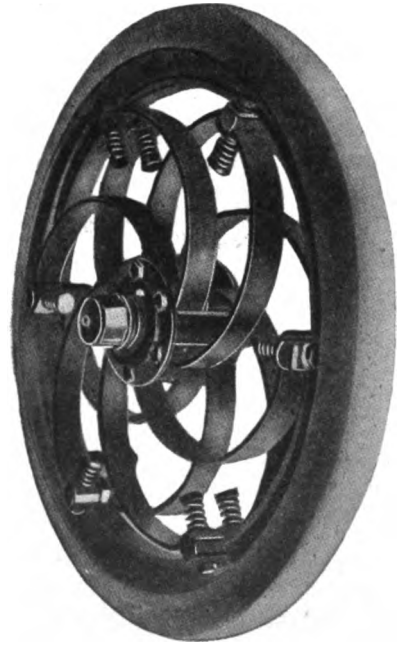


SPRING SUSPENSION—GERMAN.



OPPOSED CRESCENT FLAT SPRING SPOKES—FRENCH.

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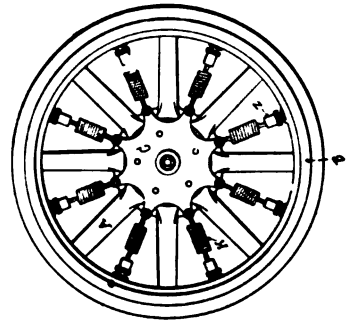
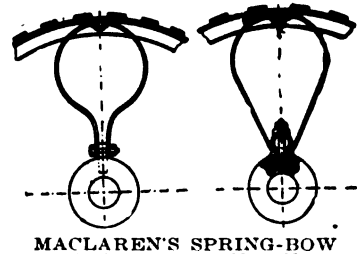
light wooden spokes placed at a tangent with the hub. His wheel has been quite successful, being used now by a number of the great transportation companies. The slender, tangential wooden spokes developed a surprising resilience. Thornycroft worked out his wheel on the principle of what might be called the double opposed dish. The spokes are formed by cutting sectors out of two flat steel plates, dishing these and riveting to



GUINGER SPIRAL SUSPENSION—FRENCH.

the rim with the bulge outward. Boulanger has also utilized a part of this idea in France, though he uses wooden spokes. Thornycroft's seems to be the most practical idea that has yet been proposed for heavy vehicles, and it might also be adapted, in some measure, to light automobiles. Besides being capable of considerable resilience, it cannot buckle, is simply and cheaply made, cannot get out of order, and the principle is such that



MACLAREN'S SPRING-BOW SPOKE SUSPENSION (1884)—ENGLISH.

it will probably stand the frightful twisting strains to which all drive wheels are subjected, better than any type yet on the market. The fact that the rear wheels, which ordinarily drive an automobile, must do work of a far different kind from that done by the front wheels, which merely bear weight, is too often unknown to or neglected by spring wheel inventors, with consequent immediate and total failure.

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The call for spring wheels for pleasure motors was not heeded until this year, practically, but within these few months the subject has attracted general attention. At various trials in Europe, there have been entries of this class, but all were more or less disappointing. In the tests made by the Automobile Club of Great Britain and Ireland, covering 4000 miles, the Halle wheel was generally thought to have done well. The spring wheel contest held in France in the spring of 1906 probably aroused more interest than any other yet held. It was organized by a prominent automobile journal in Paris, and was widely heralded, though the results were somewhat unsatisfactory.

This contest had 13 entries, though two forfeited, and the Spherola outfit, from England, was put out of the race by an accident while landing at Boulogne. Of the 10 which started, 6 depended, for their elasticity,

THORNYCROFT TRUCK WHEEL
DOUBLE-DISHED—ENGLISH.

upon some use of rubber, while 4 used metal springs only. As it happened, the only 3 which finished were of the rubber type, while the metallic spring types broke down early. Still, various circumstances rendered the general results valueless; and it is chiefly because the contest is to be repeated, that the results are criticized here.

It is true, of course, that it is the business of a spring wheel to keep on running, since only in its superior reliability can it compete with the pneumatic tire. For immediate purposes, however, three of the types; namely, the Yberty-Merigoux, the Securitas, and the Ducasble, must be excluded, since these are to be classed with cushion tires and not spring wheels. That left only 7 starters, 3 of whom covered the whole 1300 miles under the worst possible weather conditions, mounted on cars hastily acquired for the occasion, and with unfamiliar and un-

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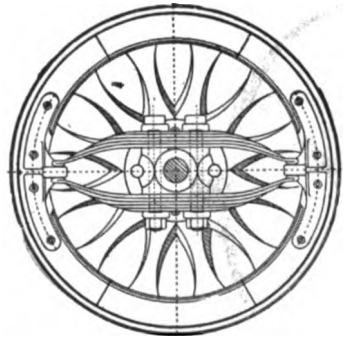
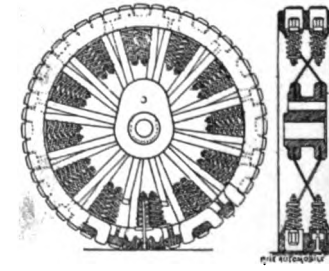
skilled drivers. The probabilities are, too, that the cars were not in the best condition, since most of the accidents occurred to the cars, rather than to the wheels. If it be true that the alleged vibration and unusual strains caused these accidents, then the wheels are at fault; but this has not been shown. In any race of 1300 miles many cars break down, even when running on the best pneumatics. The two English Halle wheels were not meant to go on 4000 pound cars, yet they easily made a speed of 50 miles an hour over muddy roads, one of them being put out of the race by a broken ball bearing, while the other Halle outfit lost because of a broken coupling. All repairs had to be taken out of the running time. The Edmond-Levy outfit lost 14 hours on accidents to the car, and only 10 minutes because of the wheels, which had to be oiled once. The English Cadignan outfit fell out because of a broken steering, and many of the



THORNYCROFT LEAF SPRING TYPE—ENGLISH.



MACLAREN SPIRAL SUSPENSION (1884)—ENGLISH.

mishaps suffered by the other cars were due to running into ditches and hitting curbstones and big rocks on the road.

There are not counted among the 10 starters the 3 cushion tire wheels. Of the 7, the two Halles, the Cadignan, and the Monnin-Damidot relied for their elasticity upon metal springs. The Edmond-Levy and the Garchey depended upon interior rubber cushions, while the Soleil had a pneumatic hub. The Soleil weighed 125 pounds; the E. L., 136 pounds; the Garchey, 191 pounds. In the case of the Garchey and the Soleil the weight is massed around the hub (contrary to the pneumatic tired wheel), though in the E. L. the weight is better distributed. All of the starters had solid rubber tires, for road grip rather than elasticity.

During the recent British 4000 mile speedometer trials, the entry fees for tires and wheels were so high that these were practically excluded. In the Pradeau wheel, one of the entries, the ordinary style of

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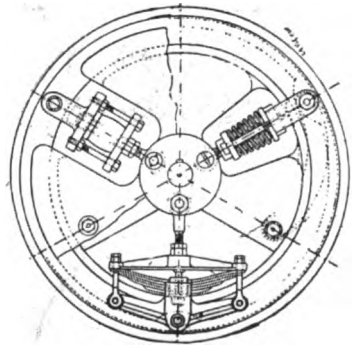
artillery spokes are let into the hub in the regular manner, but extend toward the rim for only half their length. Where the chamfering of each spoke ends a steel collar is shrunk onto the wood, in the same way that an iron tire is shrunk onto the felloe. Anchored to the steel collars are most substantial spiral springs, of a length sufficient to extend from the collars to almost the extreme periphery of the rim. The material in actual contact with the ground is a strip of solid rubber; canvas of about half the thickness of the rubber is vulcanized thereto, and within this canvas is a steel rim, flat in section, following, of course, the curve of the rubber tire. Equidistant upon the inside face of the steel rim round plates are fixed, of the same diameter as the spiral springs, these plates forming the anchorage for the springs. The rubber tire, canvas, steel



AN 1885 THREE TYPE SUSPENSION —FRENCH.

rim and springs float within a steel felloe, this latter being the portion in the illustration through which the twelve large half round bolt heads pass. The inner face of the felloe toward the hub has 12 circular steel casings screwed to it, the spiral springs previously mentioned being contained therein, the casings extending nearly through the felloe. Another British spring wheel which has attracted much attention is the De Hora, made in London.

The Middleton pneumatic hub has been favorably received in England. This hub requires a special wheel, which also wears a solid rubber tire. The hub is best described as a small pneumatic tire, which encircles the spindle box. The riding effect of a regular pneumatic tire is thus gained, so it is said, without the danger of a puncture. In fact, it is a pneumatic tired wheel, though the pneumatic never comes in touch with the ground. The wheel does not seem to show any tendency to

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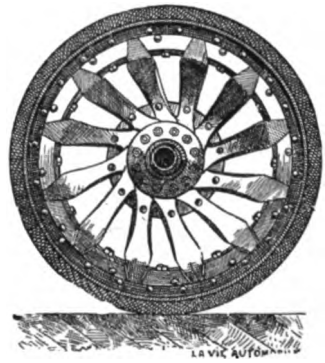
buckle. The speed and resilience are nearly equal to that of a regular pneumatic with much greater security and longer life.

Germany has not been much interested in spring wheels, Dr. Borchers, of Berlin, having done most in this line. We show two of his wheels, both being of the spring suspension type, one bearing on coiled and the other on flat steel springs, the latter being placed at an angle to the



GARE TANGENT WOOD SPOKES—ENGLISH.

AVELING HORIZONTAL SUSPENSION SPRING RIM —ENGLISH.

plane of the wheel, to guard against buckling under side strain. The wire wheel bears a simple iron tire, while the other runs upon a flexible steel band, which last also adds resilience.

The Americans have only lately become interested in spring wheels, but have developed some good types. One of these, made by Middleton and Robison, consists of a hub, a rim, and four spokes, each with a com-

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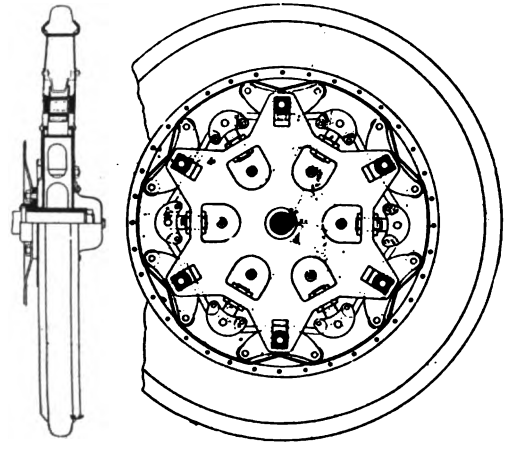
pound spring contrivance. The spokes are made in several pieces. A short, rigid bar or plunger, proceeding from the hub, plays against a coiled spring contained in a cylinder. This cylinder is itself attached to the rim by two secondary plungers, which likewise play against springs held in the cross arms of the spoke cylinder. There are, then, 3 springs on each spoke, or 12 in all. At least 7 of these are always in play, and they take up shocks effectually. The wheel also wears a solid rubber tire. The inventors have tested the wheel thoroughly on a motor car, having driven one set 1500 miles, with entire satisfaction.

The De Jarnett is also an American wheel. As will be seen from the illustration, the elasticity is secured by means of ten coiled springs interposed between the hub and the felloe. The wheel has five extensible



EMPIRE COMPENSATING SPRING—ENGLISH.

spokes, consisting of radial steel rods cast integral with the outer hub plates, the outer ends of which slide in ball bearings in a steel socket fastened to the rim. The tension of the springs is adjustable by means of a pipe wrench, as the springs are screwed on short blocks extending from the hub and the felloe, respectively. The blocks are pivoted on brackets fastened to the hub and the felloe, and the rim is made of 6 thin steel plates, instead of being made solid, in order to reduce weight.

The Iron tire pneumatic wheel obviates the possibility of punctures, at the same time affording great resilience and speed, and contributes materially to the safety and comfort of the persons occupying the vehicle. It is a wheel within a wheel, the outer tire being of iron or hard rubber, the pneumatic tube being securely encased within the wheel 8 or 9 inches above the shoe. If the pneumatic tube should collapse, the

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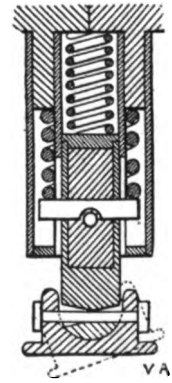
only result would be a slackening of speed, the wheel not changing its diameter or shape in the least.

The weight of the car is suspended and distributed through the upper half of the wheel and is in front of and above the center. The great strength and rigidity of this wheel is due to the fact that it is built with a 3 point suspension or triple arch. There are 48 spokes, each capable of sustaining the entire weight of the car. For trucks, sight seeing autos and other heavy motor cars, the oval iron shoe is used, while the lighter pleasure vehicles are equipped with rubber tires.

The Cliff spring hub is in 3 main parts; a false journal, in which is lodged the spring; the box end of the axle, which engages and plays upon the spring; the regular journal, in which the false journal turns on ball bearings. The false journal, which contains the spiral spring, has a



WOODFORD PILKINGTON
TELESCOPING SPOKE
—ENGLISH.

large opening for the axle to enter and play freely. A steel guide rod runs through the false journal and through the spiral spring. The box end of the axle fits around the upper part of the spring and the guide rod, having a free up-and-down motion, but no side play. The false journal is also held in the raceway against side play, though revolving freely upon the ball bearings.

Two very recent types of American wheel are also shown, though there may be doubt about their ability to stand the great twisting strains, to which drive wheels are subjected. They might, however, be serviceable as front wheels. The cuts are too clear to need description.

By way of conclusion it may be suggested that spring wheels, as a class, deserve the attention of all automobilists. Some of them are good now by any standard, and all are susceptible of improvement. Inventors

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should constantly bear in mind what is required of driving wheels, and strengthen them against buckling and the terriffic torsional strains due to sudden stops and starts. Any oscillation of the rim around the hub is apt to be disastrous to the machinery, and steel parts should not play against each other. As a matter of fact, most spring wheels now made will take up a heavier jolt than a pneumatic, and ride about as easy; but inventors should remember that it is the vibration, so well absorbed by the pneumatic, that destroys the machinery by crystallizing the steel from which it is made. Pneumatic hubs absorb vibration very well, and it is probable that the solution of the problem lies along this line, rather than in the use of metal springs.

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CHAPTER XXIX.

SAFETY OF ROADS FOR TIRES.

THE safety of the road for rubber tired, or indeed for any vehicle, is a function of several variables, without a knowledge of which no one can form any just estimate. In the final wind up the speed and weight of the vehicle, the elasticity of the springs, shock breaking fitments, the length of the wheel base, the question of front or rear drive or horse propulsion, the efficiency of the brakes, the length of the axle, the size of the wheels, the hardness and shape of the tires, and the skill of the driver have as much effect as the character of the road surface and the general layout of the road, judged by its hills and bends. This does not complete the list of influences which bear upon the general result of road safety, but it gives a fair idea of the complex conditions.

Road law must decide, in cases of dispute or accident, upon whom the responsibility and the burden of proof lie. The makers and the users of the road have mutual rights and duties to and from each other, and the users also must respect each others' rights. The makers must furnish a survey and a surface which make the road reasonably straight, level, and smooth, regard being given to the character of the traffic which it will probably bear. Whether the road makers be a private corporation or the state itself, the private owners or the public officers are responsible for the fulfilment of these conditions. On the other hand, the wayfarers undoubtedly rest under certain obligations toward the road builders. Unforeseen classes of traffic, such as traction engines, and unreasonably heavy or very narrow tired vehicles, may be excluded from the road, or their use of it restricted to certain weather conditions or to the night time. Vehicles traveling at unreasonable velocities, which are not easily controlled, or vehicles using spiked tires, sled runners or other means of road contact, unusual or unknown to the makers of the road at the time of its construction—these as well as other possible and unforeseen types may be excluded or their use restricted, either on account of undue damage resulting to the road or of undue inconvenience to the other wayfarers.

The law cannot fix limits of speed in either direction, beyond requiring that these be reasonable. The principle of the king's highway has been applied to all roads, and nobody can be restricted in or excluded

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from their use without due cause. On the other hand, no man or vehicle can stop on the road, since this would be an obstruction, depriving others of equal rights to its use. Vehicles going unusually fast or slow must have unusual regard for the rights of the customary traffic. Such vehicles are virtually an obstruction of the highway, and may be punished as such. Under the common law this is a very serious offence, having been formerly punished with death. Deliberate obstruction of the roadway is nowhere tolerated; and furious or uncontrolled driving of any vehicle constitutes a virtual monopoly of the road to that vehicle, and monopoly is equivalent to obstruction. The common law offers full remedy for overspeeding.

Between users of the road, in case of vehicles meeting, the law is generally explicit, since such cases must of necessity be of constant occurrence. Throughout the British empire, meeting vehicles turn to the left; elsewhere, they usually turn to the right. In passing, the foremost vehicle must turn out only if it be going unusually or unreasonably slow. If the passing vehicle be going unusually fast, it must pass the other as best it can and without disturbance.

It is apparent to any one, that there is a great difference in the size and strength of vehicles or other users of the road. This disparity would lead to inequalities repugnant to the common law, were there no restraining tendencies. In the United States, the restraining tendency is supposed to reside in the instinct of the people for fair play and equality. Wherever this ideal is still strong, the users of the road have been able to get along peaceably, without interference from the government, so that the written law is generally silent on this point. In certain communities there is shown a decided inclination for the heavy traffic to ignore the rights of others, but this is unusual, and does not represent the American spirit or laws. There is also a tacit understanding in American law that the individual is generally able to care for himself, both the interpretation and defence of their rights being left with the citizens themselves. This is a greater trust than is allowed to British subjects, so the common law, which is ever favorable to the weak, lays the responsibility upon the heavier and faster vehicle. The reason is that the common law antedates the use of vehicles of any kind on the road, when the great majority of persons walked. In America the roads were built primarily for horse drawn vehicles, sidewalks being provided for pedestrians, where necessary. Vehicles or pedestrians who invaded each others' exclusive domain, did so at their peril. The only clash comes at street crossings, where road and sidewalk coincide. This has been a constant source of uneasiness, accidents, and litigation, and will continue to be until the general principle has been settled at law in favor of the pedestrian. In Europe it has long

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been settled in favor of the vehicle against the pedestrian, just as Continental law always favors the strong against the weak. This difference between the Continental and English law is the product of historic evolution, government being, in the one case, for the benefit of the governors, while in English speaking countries government is supposed to be for the sake of the governed.

As has been said, the safety of the road depends upon many things, speed being among the most important; one which is good for vehicles running at a moderate speed may well be unfit for those going at a much higher speed. Everybody wants good roads, and they generally agree on what is meant by that term. It is indisputable, however, that the standard of goodness in road making rises faster than the means of accomplishment. A road which is good enough for the immense majority of its users may fairly be accounted good in law. Consequently, the contention of a comparatively few drivers of high speed motor vehicles that all roads should be made suitable for their particular uses, will not hold good and justifiable in law. All of us want roads that are broad, straight, long, level, hard, and smooth; and though experience has shown that road making is the best paying of all public investments, and that the state might even afford to run ahead of present demands, there are limits to this, both in theory and practice. Easy communication is the hope of the world and the invariable beginning of better things; but better than improving already good roads is the bringing of others up to their standard. If the excessive improvement on a particular road comes from private enterprise, well and good; but the state must have regard rather to extensive than to intensive improving. For a few automobilists to demand that the public roads, which are good enough for the public purposes, should be immediately made fit for their private purposes at great public expense, is altogether unreasonable, however good the end itself may be. Even should the automobilists come to be the majority, their ambitions might still be uneconomical, and thus oppressive to the minority, and to themselves really. To be sure, the best roads of the world have been uneconomical, being made for military purposes, and thus standing as proofs of slavery, instead of prosperity. This is true of the French and Swiss roads, the best in the world, by all accounts, the greatest of these having been built during the darkest days of their political life.

The Maysville road, the bill for whose nationalization was vetoed by President Jackson in 1829, marks the highwater mark in American road building. The road was really uneconomical, for its builders were driven by passion. It is 70 miles long, 50 feet wide, graded like a railroad, and sometimes without a bend for distances of 10 or 15 miles. Unlike the

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ordinary macadam, the road was made by the simple but expensive process of laying down 18 inches of crushed limestone. As a result, the cost of upkeep has been very low, and the project may have been justifiable in those days, before the era of railroads, when roads were a public necessity, instead of expensive toys, as they seem to be nowadays. High speed motors are regarded by most men as dangerous toys, which it is probably unwise to encourage. Accordingly, when the motorists raised the cry for better roads, the authorities retorted that the motor cars tore the face off of the roads quicker than any other type of vehicle. This was a great surprise to everybody, and many refused to believe it; but there is some proof that the statement is well founded. During the Auvergne circuit, it is claimed that many of the newer parts of the road, especially on the curves, were torn up bodily by the flying cars. Showers of small stones were dislodged by every car rounding these curves, so that the chippings and binding material, so necessary in surfacing, were completely stripped from the road at the sharper bends. It is this valuable top dressing that suffers so much from spiked tires, especially in wet weather; though some road experts claim that the suction from smooth tread pneumatics is hard on roads in dry weather. The clouds of dust raised by low hung cars at high speeds would seem to bear out their contention; and the rapid wear upon the tires in the Grand Prix bears witness to the considerable grinding or chafing action exercised upon the road by the driving wheels and by skidding. Farm wagons will certainly cut into roads that are not well drained, but they do not remove the road material bodily.

Up to the coming of the high powered motor cars, the key to successful road building was secured by arching the crown of the road and guttering the sides, so that rain would run off to the side without gathering strength to scour it, as it will do when it is allowed to run down the middle of a hilly road. Properly crowned, it was found that roads suffered less on the hillsides than in the bottoms, which is not true of flat roads. Roads so crowned seemed to actually improve with use; and when treated with petroleum having asphalt as its base, to keep down the dust and to shed the rain more easily, these roads were perfect, as regards the customary traffic. Heavy mineral oils did not seem to hurt rubber tires, either, though it was expected that they would. Being so well drained, the heaviest wagon traffic does not cut into them appreciably. Motor cars, though comparable in weight to a loaded farm wagon, could run on such a road indefinitely and without injury, if they would use smooth tread tires and be content with a reasonable speed. It is even probable that their effect would be beneficial, on the whole; but as it is,

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the behavior of some motormen has succeeded in arousing the antagonism of the makers as well as the users of the roads, and in so doing has given a backset to the whole good roads movement. It would be hard to bring against the speed maniacs any worse charge than this.

The rapid grinding off of our dearly bought road surfaces by motor cars has, as has been said, introduced a new problem in road making. To meet these new conditions, two widely different schemes have been proposed. One of these has to do with building separate roads by and for the automobilists alone. This, as everybody knows, was the solution of the locomotive problem, when it first appeared in England, and the locomotive problem of 70 years ago was almost identical with the present automobile problem. In each case, the power vehicle made demands upon the road that were and are considered incompatible with the rights of road users and road makers as well. Persons who view the matter in this light say that if motor cars require a special kind of road, then let them build their own roads for their own use. To be sure it is good economic doctrine, that when two uses of an instrument are in conflict or even widely different, it is better to have two instruments for the two purposes. A road which seems straight and level for a horse and buggy or a wagon, will seem both rough and crooked to a motor car running at top speed. With rigid wheels and tires, a motor car will be racked to pieces at a speed which would be only pleasant in the same car shod with good pneumatics. It is astonishing how a high speed car will bring out roughness and bends hitherto unperceived in a road that was thought to be perfect. This means that the adaptation of ordinary roads to such vehicles is practically impossible, and that it would not be economical to the commonwealth, even if it were possible.

There are those who would let the motorists build their own roads and use them as they see fit; but they insist that if motors are to run on the public roads, they must conform to the requirements of the customary traffic. The opposite idea, proposed by road experts, is based upon a study of road surfaces acted upon by high speed motor cars. The smooth surface, so hard to get on turnpikes, may be firmly supported from beneath, but it has no lateral cohesion. The wheels of horse drawn vehicles, which merely bear weight, act only vertically upon the surface, which is the direction in which it is most firmly supported; so that injury can only come from excessive and unforeseen weight, or from unreasonably narrow tires. The iron shod horse does some damage, probably; but his weight is not considerable, and the smoother the road, the less will be his tractive effort. The wheels of the motor car, in securing traction and in skidding, exert their action laterally upon the road surface, the direction in which

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it has practically no cohesion. Consequently, self propelled traffic would tend to destroy this surface rapidly.

The remedy proposed for this tendency is to furnish the necessary lateral coherence to the road surface through blending with it some tough substance, like asphalt or tar. One proposal is to dip the rock chips, customarily used for the top dressing, in hot tar and then roll them as usual. This is called tarmac; slag or even cinders are sometimes used instead of rock chips. The other and more popular method is to simply spread hot tar upon the top of a well made turnpike while it is dry and free of dust. In this way the liquid tar soaks into the roadbed to a certain extent, when it hardens and forms a kind of matrix or tough bond between the fine fragments composing the road surface. This makes of the surface a tough conglomerate, which acts as a unit in resisting the driving strains and side thrust from the wheels of the motor. It also smooths and "quietens" the road to some extent, and prevents much of the customary dust; but with this difference that the tar dust makes up in destructive quality what it lacks in quantity.

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CHAPTER XXX.

WHAT BECOMES OF WORN OUT TIRES.

WHAT becomes of all the automobile tires, when once they are worn out? The best of them cannot last as long as a well made and well cared for automobile, and hundreds of thousands if not millions of these heavy rubber bands have been discarded since motoring first began. What becomes of them? Worn out tires are not absolutely thrown away, but so long as any rubber remains it continues to find new uses. It may be consoling to the motorist, however, to be assured at the outset that a tire is never a tire but once, though a discarded tire may be encountered again and again in the shape of a great variety of other articles made of rubber.

It should be understood that only high grade rubber is used in the manufacture of automobile tires. That being the case, it is natural that when tires are discarded they should be in demand by the people who "reclaim" rubber. Hence a more or less systematic trade of large proportions has grown up in these articles. The junk dealers, small and large, are constantly on the lookout for old tires, and now and then one of them gets into trouble on account of acquiring a tire that has not become worn out. The junkman pays as small a price as possible, loads the tire on his pushcart, or, if he is in trade in a large way, on his wagon, and carts it off to the cellar which he uses as a sorting room and warehouse. There it lies until he has accumulated enough others to make up a lot worth while, when he sends it to a dealer in "scrap rubber." He, in turn, ships his collection in carload lots to the mills where rubber is reclaimed.

So it is seen that while a tire may be cast aside as worthless by the tire dealer or repairer, it still has an intrinsic value. The price of such material, however, varies with circumstances. Large handlers of tires in New York have sold worn out ones left on their hands as high as 7 cents or more a pound. But these men do not start their tires to the reclaimers through the medium of the small fry junkmen. Then the market for old rubber, as in the case of all other commodities, fluctuates, prices being governed by the law of supply and demand. Sometimes the reclaimers want pneumatics, and sometimes they are more in need of solid tires, because different "stock" is required for producing different grades.

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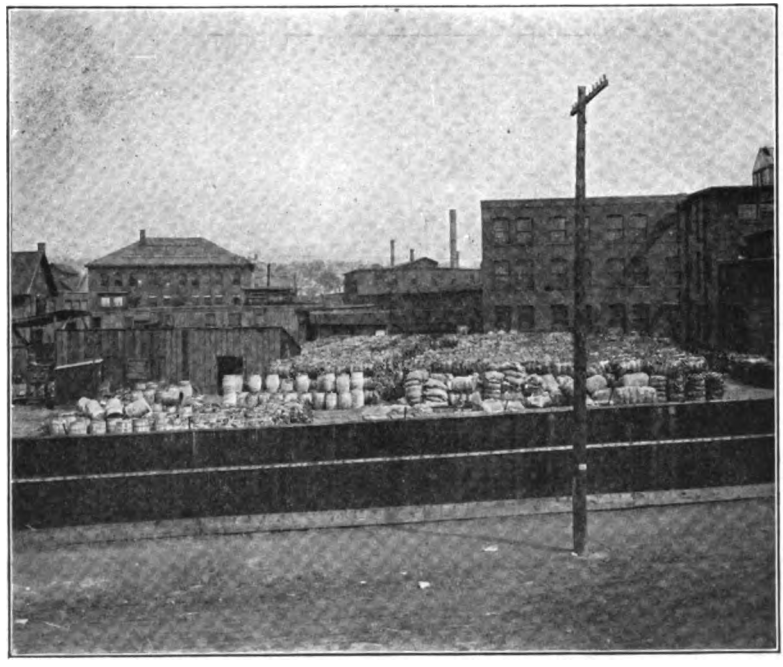
Some of the New York houses at which old tires accumulate, when the motorist has been supplied with new ones, dispose of the waste material under contract. But where there is no such contract, the tire people do not have to worry about disposing of their old stock, as there are junkmen waiting all the time to carry it away and pay the prevailing market price. Dealers do not always make profit in the stuff, but they have to handle it, because if they don't take the old tires off they can't put new ones on.



WASTE RUBBER WAREHOUSES—ENGLISH.

At a warehouse that is devoted to the reception, storage, and shipping of rubber scrap, the manager said:

"We do not let this stock accumulate; in fact, we do not have a chance to. As fast as we get enough stock to make it worth while we ship it to some reclaiming works. Reclaimers distinguish between solid and pneumatic tires, sometimes paying more for one than for the other. We have nothing to do with gathering up the old tires. They come to us in the regular way, with all sorts of rubber that is brought in by junkmen. The junkmen bring the stuff to our door and we pay them the market price for it. Some reclaimers do not use old tires, however, but

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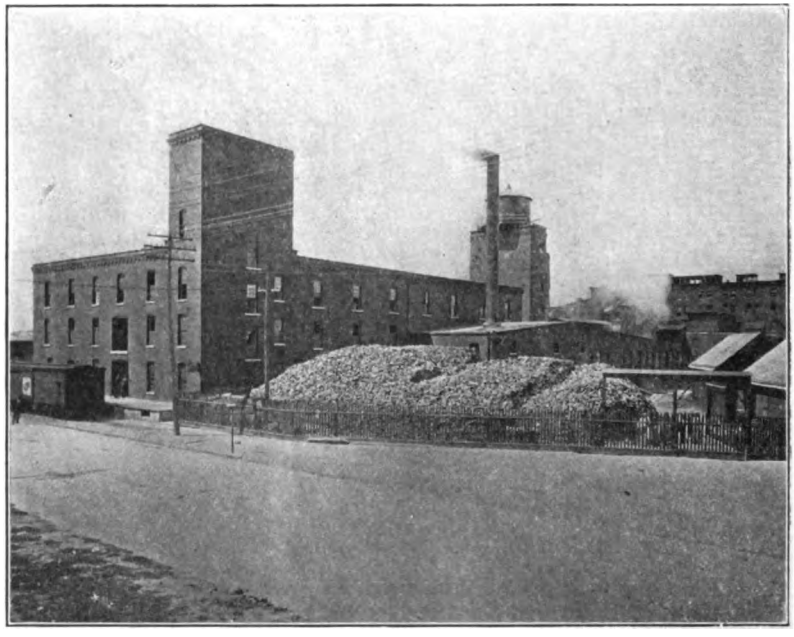
we have no trouble in disposing of all we can get at good prices, and the demand is increasing."

In England, where many rubber manufacturers make their own reclaimed rubber, considerable tire stock is used for this purpose. Hence some of the large tire makers have entered into arrangements whereby all the castoff tires accumulating in the hands of their customers are taken at the market price, the proceeds being credited against the customers' accounts. So important a consideration is this that sometimes a year's



RUBBER RECLAIMING WORKS—AMERICAN.

contract for new tires is determined by the liberality of the manufacturer in accepting castoffs for his reclaiming requirements.

The high price of new rubber, as compared with former conditions, has led to a great demand for everything in the shape of rubber. Hence science has been led to evolve processes whereby the rubber in worn out goods can be separated from the fabric combined with it in tires, overshoes, and the like, and turned to use in the shape of "reclaimed" stock. The amount of such material now used is very great, requiring the constant operation of many reclaiming works. Insignificant as a discarded rubber shoe may seem, such is the demand for rubber that very few of

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these are overlooked by the junkmen throughout the United States; even the cast-away rubbers of Russia and the rest of Europe find their way finally to the rubber reclaimers. The use of old tires for a similar purpose is comparatively recent, and as yet their consumption has not been taken up by some large reclaimers. There is no probability, however, that old tires will ever become a drug on the market. It may be added that reclaimed rubber is valuable as a "filler" for use in compounds for many kinds of rubber goods—being superior, in fact, to some of the materials used before its discovery. It is not used in the place of new rubber, but only in conjunction with it. It is not adapted, however, to use in tires, by reason of its lack of elasticity and tensile strength—qualities less essential in some other goods.

The work of reclaiming rubber was first developed in the United States, where it is still larger than in any other country, though the industry is growing in Europe. There are particularly large rubber reclaiming plants at Buffalo, Naugatuck, Akron, Boston, and Philadelphia, besides a number of smaller ones, catering to the general trade, in addition to which some rubber manufacturers have their own reclaiming outfits. In Europe there are large reclaiming plants in England, Denmark, and Russia.

Many patents have been issued for rubber reclaiming methods. There is a mechanical process, which involves grinding the waste, blowing out the fiber, and steaming the rubber which remains, to overcome the effect upon it of the surphur used in vulcanization. The larger output of reclaimed rubber, however—and that which covers the consumption of most of the tire stock used—results from the solution process. Briefly described, this consists in treating ground scrap with a dilute alkali solution at a comparatively high temperature, then washing, drying, and sheeting. The first result is that any cotton or other fiber that may be present is destroyed, but without affecting the rubber injuriously. Any oils or "rubber substitutes" that may have been used in the manufacture of the goods are either destroyed or dissolved out. A further effect of the treatment is upon the sulphur in the goods, whereby the rubber is rendered capable of combining more readily with new rubber.

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CHAPTER XXXI.

SUBSTITUTES FOR INDIA-RUBBER.

SO often has the announcement appeared in the daily press that a genuine substitute for rubber had been discovered that the true story should be told. Particularly is it apropos because in almost every case with the news of the new discovery is the added information that the substitute is capable of being made up into cycle and automobile tires.

Since india-rubber first became of value through vulcanization it has been the dream of experimenters and inventors to produce it artificially. One of the most persistent seekers after a substitute for the natural gum was the late Austin G. Day, who tried hundreds of experiments and took out many patents. As far back as 1866 he made public the results of some of his work, giving as formulas for rubber substitutes the following compounds:

No. 1.

Linseed oil	2 pounds
Cottonseed oil	1 pound
Petroleum	2 pounds
Raw turpentine	2 pounds
Sulphur	2 pounds

[Boil 2 hours.]

No. 2.

Linseed oil	2 pounds
Cottonseed oil	1 pound
Petroleum	1 pound
Raw turpentine	2 pounds
Castor oil	1 pound
Sulphur	2 pounds

[Boil ½ hour.]

No. 3.

Linseed oil	2 pounds
Cottonseed oil	1 pound
Petroleum	1 pound
Raw turpentine	½ pound
Liquid coal tar	3 pounds
Peanut oil	1 pound
Spirits turpentine	1 pound
Sulphur	4 pounds

[Boil 35 minutes.]

No. 4.

Linseed oil	2 pounds
Cottonseed oil	1 pound
Petroleum	2 pounds
Raw turpentine	½ pound
Liquid coal tar	2 pounds
Spirits turpentine	1 pound
Rubber	¼ pound
Sulphur	2 pounds

[Boil 1 hour.]

A substitute designed to be used in rubber compounding in place say of reclaimed rubber was made as follows:

Cottonseed oil	27 pounds
Coal tar	30 pounds
Earthy matter	5 pounds

—to be mixed and heated to 300° F., and then strained and cooled to

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200° F. Then were added 27 pounds linseed oil, the heat raised to 220° F., and 15 to 18 pounds of sulphur added, the heat being continually raised until the mass was sulphurized. When the heat reached 240° F., 1 to 1½ ounces of nitric acid was added, and at 270° to 280° F., from 1 to 3 ounces camphor was added to help the sulphurization. The resultant compound was used on the following basis:

Pará rubber	20 pounds
Litharge	5 pounds
Sulphur	1 pound
Above compound	20 to 40 pounds

Mr. Day, however, did not insist on the compound quoted, but advised that the proportions be varied as widely as the exigencies of the case might demand. Whiting, barytes, infusorial earth, white lead, blacks—in fact, almost any of the oxides, carbonates, or earthy materials commonly used in compounding, were used in connection with his substitute, as also were any grades of crude rubber. Among other ingredients that he found of use in making his substitutes were vegetable and animal waxes, together with ozocerite and paraffine. These, however, were only used in small quantities, and always in connection with the linseed and cottonseed oils, and generally asphaltum or coal tar. One of his compounds also called for a quantity of golden sulphuret of antimony, presumably to assist in the sulphurization, and a small amount of tannic acid.

The record of Mr. Day's experimenting, unfortunately, is imperfect. Were it complete it would show that he drew upon almost all the ingredients then accessible, and that some of the results reached were very curious, and numbers of them of value.

Another line of experimenting that is interesting is in the use of cellulose. A very simple formula is of French origin and calls for the treating of cellulose with sulphuric acid, washing, drying, granulating, treating with resinate of soda—which is afterward precipitated by sulphate of alumina—then drying and molding under pressure. As a matter of fact the resultant mass would not be mistaken for rubber. An English formula consists of—

Cellulose	15 pounds
Pitch	25 pounds
Asphalt	20 pounds
Silica	20 pounds
Mastic	5 pounds
Bitumen	5 pounds
Resin	10 pounds
Coal tar	12 pounds

This makes a thick, gummy varnish, which is of little use except for its weatherproof qualities. Allen's formula for a cellulose substitute

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might have a value if it were carried further. It is made up of 100 pounds of resinous wood pulp treated with animal gelatine, 100 pounds asphalt, and 10 pounds asphalt oil, all heated and molded.

The Greening process, which is English, is more elaborate than Allen's, but laborious and costly. This process calls for the treatment of the cellulose by a mixture of sulphuric acid and nitrate of potash, and, after drying, a treatment to a bath of liquid carbonic acid. When dry again, it is mixed in a retort with refined resin, gum benzoin, castor oil, and methylated alcohol. The distillate from this is dried by redistilling over anhydrous lime.

Another curious line of substitutes is that based upon the use of glue and glycerine. Some of these have uses, while others, that look very attractive, are of no use at all, for the simple reason that they will absorb water almost as readily as a dry sponge. The first of these is more than thirty years old and is said to be of French origin. The formula is:

Glue	4 pounds
Glycerine	8 ounces
Nut gall	3 ounces
Acetic acid	1 pound in 5 pounds of water

Ten years later this was approached by an English formula in which in place of the nut gall and acetic acid, chromic and tannic acids were substituted, and a modicum of ground cork was added as a cheapener, probably. Some four years later an ingenious Prussian gave out a formula in which to the glue and glycerine and tannic acid were added Marseilles soap and linseed oil. None of the above have ever had a commercial value, the nearest approach being the glue and glycerine compound used as a cover for gas tubing.

The substitutes that have really come into use generally are made either from linseed, cottonseed, or maize oils. Scores of these have been produced and thousands of dollars have been spent by promoters and owners in trying to make these gums do just what crude rubber will. A German formula that cost certain American investors thousands of dollars, and which for a time looked as if it would be generally adopted, was—

Linseed oil	80 pounds	} in solution.
Lime hardened resin	50 pounds	
Sulphur	8 pounds	} add to above.
Linseed oil	42 pounds	

Add 20 pounds sulphur and heat to 375° F.

This gum, although used quite largely at one time in the United States, France, and Germany, is not manufactured now. As a rule, substitute is made of one of the oils named above and may be generally divided

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into two grades: (1) the brown (or black) and (2) the white. The former is made by heating one of the fatty oils with sulphur; the latter is made by treating the oil cold with sulphur chloride.

In conclusion it is only fair to the great tire trade to say that not a pound of any of the alleged substitutes for rubber goes into automobile tires. In very poor grades of cycle tires there is sometimes a little used, but never in good tires. Further than this, it is proper to say that there is today no real substitute for rubber and probably never will be.

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CHAPTER XXXII.

WHERE RUBBER TIRES ARE MADE.

UNITED STATES.

THE largest center of the rubber tire manufacture in the United States is at Akron, Ohio, where the rubber industry was established about 1870, the pioneer plant having developed into the great establishment of The B. F. Goodrich Co. Always enterprising and successful, this company have added to their list of products until it now includes nearly everything made of rubber. Early in the history of the bicycle trade the Goodrich company took on the manufacture of pneumatic tires, and later they have manufactured tires of all the leading types for vehicles of whatever kind, and they have given special attention to the production of automobile tires. A prominent feature of the Goodrich company's factory is its systematic division into departments, the tire department having become one of the most important. The Goodrich company have always been prompt to become licensees under new tire patents that promised to become worth while, so that they have been in position to supply practically any demand for rubber tires of whatever type. Besides manufacturing for their own trade they have done a large business in manufacturing under contract for patentees of many tires. The B. F. Goodrich Co. are capitalized at $10,000,000.

It is not clear that Akron had any special advantages to commend it as a rubber manufacturing site until the success of the pioneer factory became so pronounced, since which time nearly a score of rubber factories have grown up there, several of them making tires. One of the three largest rubber tire concerns in the country is that of The Diamond Rubber Co., whose capitalization has grown from $50,000 in 1894, to $3,000,000. The Diamond company also have pursued the policy of taking out licenses under the more important patents for tires of all classes —for bicycles, carriages, automobiles, and trucks. The Diamond company are extensive makers also of mechanical rubber goods.

The Goodyear Tire and Rubber Co. are third in the point of age among the rubber tire plants in Akron. The company also make mechanical and other rubber goods, but have developed their tire trade on larger lines than the other departments, embracing practically all the types of

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tires now in use, and showing much enterprise in bringing out new features.

From time to time a new tire, at first made under contract for the inventor, has met with such success as to justify the establishment of a factory for producing it alone, and this has been true particularly in Akron. The Firestone Tire and Rubber Co., organized to sell a solid rubber "sidewire" tire, invented by Byrider and Swinehart, in 1903 began manufacturing tires in a plant of their own, where they are now making pneumatic automobile tires also.

Similarly at Akron have grown up the tire factories of The Swinehart Clincher Tire and Rubber Co., to manufacture a later invention of James A. Swinehart than his "sidewire" tire; and the Stein Double Cushion Tire Co., for the production of a special patented tire. There must be mentioned also the Akron factory operated under the name Buckeye Rubber Co., owned by the Consolidated Rubber Tire Co. (New York), and manufacturing the tires on which the latter control the patents, particularly the A. W. Grant patent on solid rubber internally wired on tires. Each of the factories mentioned in the last two paragraphs is devoted solely to making tires.

Two other factories in Ohio which make tires are engaged likewise in producing a general line of mechanical goods—the Cleveland Rubber Works of the Mechanical Rubber Co., among the earliest makers in America of bicycle tires, and the Republic Rubber Co., at Youngstown, founded in 1902, and recently extensive manufacturers of carriage and automobile tires.

While dealing with the West, mention will be made of the firm of Morgan & Wright, which, starting at Chicago on a very small scale, in the early days of the bicycle, developed a notable success, their production of bicycle tires in a single year being reported at $4,000,000. With the decline of cycling, this firm took on the manufacture of other lines of rubber goods, which are still continued, but their output of tires has again become important with the growth of automobiling. Recently Morgan & Wright have removed to Detroit, Michigan, where they have erected a large plant, designed throughout on the most modern lines.

The G & J Tire Co. are the owners of the patents on the American clincher tire, developed first for bicycles and later for all vehicles. A number of companies named in this chapter pay royalties to the G & J company on the manufacture of this type of tire, besides which the company market their own tires, made at the works operated originally under the name of The Indianapolis Rubber Co., at Indianapolis.

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The Kokomo Rubber Co., at Kokomo, Indiana, have been engaged successfully for a number of years in making bicycle tires, to which they have added, with the progress of the trade, a line for carriages and automobiles.

Another factory manufacturing tires in Indiana is that of the Indiana Rubber and Insulated Wire Co., at Jonesboro. The western list will be completed by the mention of the Milwaukee Rubber Works Co., at Cudahy, Wisconsin.

Coming eastward, two rubber tire manufacturers are found in Pennsylvania. The Pennsylvania Rubber Co., at Jeannette, near Pittsburgh, in addition to a general line of rubber goods, make tires for bicycles and for every type of vehicles. The same is true of the Continental Rubber Works, at Erie.

In New England the most notable rubber tire factory is that of the Hartford Rubber Works Co., at Hartford, Connecticut. This was a small concern, making specialties for the druggists' trade, when the demand for bicycle tires first became pronounced. Colonel Albert A. Pope, one of the first bicycle manufacturers, secured the plant and turned it into a tire factory, first for the equipment of his own bicycles, and later for supplying the trade. Subsequently, the factory became the property of the combination known as the Rubber Goods Manufacturing Co., under whose control it has been devoted to the manufacture of solid and pneumatic vehicle tires, as well as bicycle tires. The Dunlop tires made in America are produced at the Hartford factory.

The Fisk Rubber Co., at Chicopee Falls, Massachusetts, are devoted to making a pneumatic automobile tire which is distinguished by being of the mechanically fastened on type. The company own the patents on this tire, being among the few companies in the American list owning patents on types of tires, although nearly every company owns patents of value on means of applying tires, or some other such detail.

The Boston Belting Co., at Boston, a long established and important mechanical rubber goods concern, probably made the first rubber tires turned out in the United States, and meanwhile they have made many tires, of numerous types, but their business in tires has been mainly in their manufacture under contract.

Tires are made extensively in New Jersey by the International Rubber Co., at Milltown. Beginning with bicycle tires, under patents controlled by the company, they have gradually taken on solid and pneumatic carriage tires, and latterly automobile tires.

Two other companies in New Jersey making tires are engaged largely in the general mechanical goods trade. They are the Trenton Rubber

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Manufacturing Co., producing solid vehicle tires, and the Voorhees Rubber Manufacturing Co., at Jersey City, who make a special form of cushion tire.

The three rubber tire factories in New York state are those of The Sweet Tire and Rubber Co., at Batavia; the Niagara Rubber Co., at Lockport; and the Ajax-Grieb Rubber Co., in New York city, with a factory also in New Jersey. The latter is a co-operative enterprise lately organized by a group of automobile manufacturers.

At one time this list might have been headed by the New York Belting and Packing Co., Limited, who were among the first to make bicycle tires, in which they did an extensive business, while in their factories was done much pioneer experimental work in the development of practical vehicle tires. Later, however, their tire business was consolidated with that of other factories under the same control.

This does not complete the list of factories making tires, but those unnamed here are manufacturers for the most part under contract, and as a rule their names do not appear in the tire trade. The different companies are all independent, with the exception that four are comprised in the Rubber Goods Manufacturing Co., which in turn has been merged with the United States Rubber Co. These are the Hartford Rubber Works Co., Morgan & Wright, the G & J Tire Co., and the Cleveland Rubber Works.

CANADA.

The Canadian tire trade has been, from the beginning, conducted energetically and with success. Practically all the types of tires which have had any vogue in the United States have been introduced in the Dominion, where they have been manufactured mainly by the Gutta-Percha and Rubber Manufacturing Co. of Toronto, Limited, and the Canadian Rubber Co. of Montreal, Limited, both of which firms are makers of a general line of rubber goods. A third concern is the Dunlop Tire and Rubber Goods Co., Limited, at Toronto. This was organized originally to market the Dunlop tire in Canada, and was encouraged by its financial success to erect a factory, for the production of tires and other goods in rubber.

AUSTRALIA.

The second rubber factory to be established in Australia was for the purpose of making bicycle tires under the Dunlop patents, since which time motor car tires have been added, and also solid tires, the latter under the Grant patent. The company, financed by Canadian capitalists, is

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known as the Dunlop Tire Co. of Australia, Limited, and the factory is located at Melbourne.

AUSTRIA-HUNGARY.

The rubber industry in the dual monarchy has attained proportions which afford a total production equal to the wants of the country; some rubber goods continue to be imported, and some made in the country are exported. Some of the more important factories have been established by German interests, to avoid the duties charged on imported goods. The leading factories making tires are Josef Reithoffer's Söhne, Vereinigte Gummiwaren-Fabriken Harburg-Wien, and Oesterreich-Amerikanische Gummifabrik, all in or near Vienna, and Ungarische Gummiwaren-Fabriks Aktiengesellschaft, at Budapest.

BELGIUM.

The long established factory of O. Englebert fils et Cie., at Liége, which probably is the largest in Belgium, in addition to a general range of rubber goods, gives prominence to the making of the Englebert pneumatics, for cycles, carriages, and automobiles. The company have branch factories in France and Holland.

For the senior partner of J. Coenen père et Cie., of Brussels, is claimed the distinction of having been the first (in 1848) to establish the rubber industry in Belgium. In 1892 he invented a pneumatic tire specially designed for protection against puncture. The factory of the company is at Cureghem.

The "Usines Jackson" (A Michel-Jackson) at Menin date from the early fifties, being due to the initiative of the late Jonathan G. Stickney, an American, who met Charles Goodyear in Paris, and through him became for the first time interested in rubber. The company are important manufacturers of pneumatics.

Tires are made at Ghent by the Colonial Rubber Sociètè Anonyme, successors to the brothers de Schampelaere. The same company have a factory in France.

Some of the other rubber works in Belgium make tires, in addition to which there are some plants of respectable size devoted exclusively to treading and retreading tires, and others to the manufacture of leather or rubber protective treads.

FRANCE.

To France incontestably belongs the credit for the development of the pneumatic tire as applied to automobiles, and, as everybody now knows, without such tires the automobile of today would not exist. It was

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the long established house of Michelin et Cie., rubber manufacturers, that first equipped an automobile with pneumatics, back in 1895. The Michelins, among the oldest and most successful rubber manufacturers in France, and already large producers of bicycle tires, were desirous, after a few automobiles had been made, of seeing rubber tires tested on them. But when the first formal automobile race was planned, not one builder was willing to have his car equipped with rubber tires, whereupon the Michelin firm had a car built in the machine shop connected with their rubber factory. It was the behavior of the rubber tires on this car—not very promising, it must be admitted—that led to the pneumatic tire becoming a part of the standard equipment of automobiles everywhere. The Michelin factory, in the ancient town of Clermont-Ferrand, in Central France, employs some 3000 persons, and, in addition to a general line of rubber goods, produces daily about 1000 pneumatic motor tires, which find a sale in every country in the world where automobiling has become known. The firm's sale of motor tires alone, in 1905, amounted in value to about $7,500,000.

Important as is the firm named above, their business does not comprise the whole rubber industry at Clermont-Ferrand. Somewhat younger, and yet established for more than a half century, are the firm of Torrilhon et Cie. Like most rubber manufacturers in Europe, this house produces a wide variety of goods—including waterproof garments—but beginning with the advent of cycling, Torrilhon et Cie. devoted themselves more especially to the tire trade, which became even more important with the development of the automobile. In addition to pneumatics, the house of Torrilhon manufactures solid tires of the sidewire type, under license from the American patentees, Byrider and Swinehart.

A third rubber tire factory of importance in Clermont-Ferrand is that of Bergougnan et Cie., established in 1894, and having now a capital of 4,000,000 francs ($800,000). The tires manufactured here, of the clincher detachable type, are known by the trade name "Gaulois."

In considering the tire production of the important firms just named, and of the other houses in the trade, it should be kept in mind that pneumatics are in demand in France not alone for automobiles. Bicycling is still in great favor in that country, as compared with the United States, while the thousands and thousands of horse drawn cabs in Paris and the other French cities are almost invariably furnished with pneumatics, all of which contribute largely to the profits of the rubber trade.

The Etablissements Hutchinson, with a factory at Montargis, date from about 1853. The business was founded by Americans, for the manufacture of rubber footwear, which continues to be the principal

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production, but in recent years the manufacture of pneumatic tires has been taken on actively. An entirely new shop was erected in 1905 for the tire department, the output of which is designed especially for automobiles.

The important English concern, The India-Rubber, Gutta-Percha, and Telegraph Works Co., Limited, have for a number of years maintained a factory at Persan, for the manufacture of the company's various productions which may be required for their trade in France. The company have been developing a business in tires here as well as elsewhere, and the pneumatics sold by them are known as the "Persan" tires.

The Dunlop company, also British, at an early period in their development organized their business in France as a separate company—Societè Française des Pneumatiques Dunlop—which now operates a factory at Argenteuil.

The Societè Industrielle des Telephones, of Paris, have at different times acquired two of the oldest rubber factories in France. One of these is devoted now to making insulated cables, and the other, at Grenelle, to the manufacture of rubber goods generally, including pneumatic tires. These are described as the "Electric" tires.

Still another electrical goods concern which has taken up the rubber manufacture, and now includes tires among its products, is the Etablissements Industriels E. C. Grammont. Their rubber goods are made at Pont-de-Chéruy, in a factory dating from 1852.

Falconnet-Perodeaud, at their factory at Choisy-le-Roi, began the manufacture of tires in the early days of cycling, continuing it and keeping pace with the progress of the automobile. They also manufacture the solid wired-on tire, under the Grant patent, an American invention.

Other French tire makers are the Colonial Rubber Societè Anonyme, at Prouvy-Thiaut; and L. Edelin, of Paris, and several smaller concerns. The use of leather protective treads for pneumatics has been largely developed in France, and several companies are devoted to their manufacture, including the "Samson" company; Dufour jeune & fils, makers of "Le Marquis" tires, and Julien Pinçon et Cie.

GERMANY.

The tendency in the rubber industry in Germany is to produce a great variety of goods in a single factory, instead of specializing, as in America. Hence there are no factories for tires exclusively, but most of the larger works make tires. The German manufacturers supply to a great extent the home demands for rubber tires of all classes, besides which a very large export trade is done. Nearly all the firms mentioned in the list

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which follows maintain selling depots in London, and most of them in several other foreign centers.

At Hanover is a very important center of German rubber interests. There is located the great plant of the Continental Caoutchouc und Gutta-percha Compagnie, makers of nearly every kind of rubber goods. They became an important factor in the tire trade in connection with bicycles and were early to discern that automobile tires would come into great demand. They were prepared for this, and their "Continental" tires have become known and are in use in every country. This is of the standard detachable clincher type, but the company also supply any kind of tire for which there is a demand. The Continental company have established a branch factory in Great Britain. The capital of the company is 4,200,000 marks ($1,050,000).

The Hannoversche Gummi-Kamm Co., organized, as the name indicates, for the manufacture of rubber combs, have gradually added many other lines of rubber goods, including toys and surgical articles. They were also early in the tire field, their "Excelsior" brand of pneumatics becoming widely known, first for bicycles and more recently for automobiles and other vehicles.

The Hannoversche Aktien-Gummiwaren-Fabrik, at Linden, near Hanover, are also manufacturing tires.

At Harburg-on-the-Elbe is located one of the great plants of the Vereinigte Gummiwaren-Fabriken Harburg-Wien (United Rubber Goods Factories of Harburg and Vienna), the largest enterprise in the German rubber industry. This concern has a particularly wide range of products. They entered the tire field somewhat later than other companies, but their tire department has been developed to the point of filling a place in the front rank of tire makers. The "Harburg" pneumatics are exported extensively. The company are capitalized at 6,000,000 marks.

Asbest und Gummiwerke Alfred Calmon, at Hamburg, are employed in the manufacture of asbestos and rubber goods generally. The company are extensive makers of tires, and have brought out a number of distinctive features.

The Actiengesellschaft Metzeler & Co., at Munich, were at first devoted to surgical goods and the like. They have now added tires, and the Metzeler pneumatic has become widely known.

The United Berlin-Frankfort India Rubber Co., with factories in Berlin, Gelnhausen (near Frankfort), and elsewhere, are one of the oldest concerns in the German rubber trade, having been founded in 1849 by Mr. Elliott, an Englishman. The company's "Elliott" cycle tires early gained a large sale, which has been repeated with their "Veritas" pneu-

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matics for motor cars. The company have also a large trade in Austria and operate a factory in Bohemia.

The Mitteldeutsche Gummiwaren-Fabrik Louis Peter, at Frankfort-on-the-Main, make a wide range of tires, both pneumatic and solid, including a number of features covered by the Peter patents.

The Dunlop Pneumatic Tyre Co., of England, organized a subsidiary company to conduct their trade in Germany, which since October, 1904, has been manufacturing tires at Hanau, not far from Frankfort. This is the only factory in the list devoted to tires alone.

The Frankfurter Gummiwaren-Fabrik Carl Stoeckicht, at Frankfort, manufacture the "Duro" pneumatics for bicycles, motor cycles, and automobiles, and the Struck solid tires. Frankfort and its environs are thus seen to be an important center of the tire industry. It is also the seat of Michelin's branch house in Germany.

Franz Clouth, of the Rheinish Rubber Works at Cologne, which he founded in 1866, has seen the business grow to very large proportions, the success attained in the other departments having been repeated later in the manufacture of solid and pneumatic tires.

B. Polack, at Waltershausen (Thuringen), manufactures the "Superior" pneumatics and patent solid tires, the latter for very heavy work.

The business of Hutchinson & Co., at Mannheim, is related to the Etablissements Hutchinson, in France, mentioned on another page. They are large manufacturers of rubber shoes, in addition to which they are turning out tires.

The Gummiwerk Oberspree, at Oberschoenweide, near Berlin, make the "Oberspree" motor pneumatics. The large Deutsche Kabelwerke Actiengesellschaft, at Rummelsberg, near Berlin, include pneumatic tires among their widely varied products—from electric cables to women's dress shields. The important factory at Gotha of the Vereinigte Hanfschlauch und Gummiwaren Fabriken (United Hemp Hose and Rubber Goods Factories) make tires. Also the rubber goods factory of Wilhelm Pahl, at Dortmund.

GREAT BRITAIN.

The pioneer rubber goods factory in Great Britain is that of Charles Macintosh & Co., Limited, at Manchester. Their first important production was the waterproof coat, which has become known everywhere as the "macintosh" or "mackintosh," from the inventor's name. From the beginning, however, this house was disposed to make any type of rubber goods for which a demand existed, so that it was natural, as soon as

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cycling came in, that they should begin making solid tires for this purpose. Later they made many pneumatic tires under contract for different inventors, but without bringing out one of their own, though they were large makers of tire inner tubes, which were not protected by any patent. Now that the principal British tire patents have expired, Messrs. Macintosh have entered the trade actively on their own account.

The extensive rubber works of David Moseley & Sons, Limited, also in Manchester, are the outgrowth of a small factory for waterproofing cloth, started by David Moseley in 1847. The present company, formed by three brothers of the third generation, and capitalized at £300,000 ($1,500,000), is devoted to the manufacture of rubber goods generally. Like the house of Macintosh, the Messrs. Moseley began making bicycle tires early, and their development into large manufacturers of automobile tires has been along somewhat similar lines. In fact, the same general description would apply to several British concerns.

The India-Rubber, Gutta-Percha, and Telegraph Works Co., Limited, with extensive works at Silvertown, London, in some respects rank first among English rubber manufacturers, and especially in respect of the variety of their products. They are important builders of ocean telegraph cables, and hold a leading place in the manufacture of golf balls, druggists' goods, and whatever rubber enters into, with the exception of footwear. The company are capitalized at £500,000 ($2,500,000), on which 10 per cent. is paid regularly, besides which £400,000 of borrowed capital is employed. The company have had much experience in the manufacture of bicycle and other rubber tires. They own a controlling interest in The Palmer Tyre, Limited, making the tires marketed by that successful concern. The company control a number of patents in respect of special tire fabrics.

The North British Rubber Co., Limited, at Edinburgh, Scotland, was founded in 1856 by Americans who had been successful at home in the rubber industry and desired an outlet for their surplus capital. The Edinburgh enterprise proved successful from the beginning, gradually taking on a wider range of products than almost any other rubber factory. The factory has long been under Scotch management, and the capital owned in America has declined to a small figure. The North British company has had a notable relation to the tire trade, through the invention by its then managing director, the late Mr. W. E. Bartlett, of the clincher tire and rim. This tire, which had great vogue for cycles, and has become practically the standard type for motor cars, is more fully referred to elsewhere in this work. The patent rights were sold to

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the Dunlop people, but the vendors retained the right to manufacture, and still figure largely as tire producers.

The Dunlop Pneumatic Tyre Co., Limited, formed originally to work certain tire patents, entered into agreements with leading rubber manufacturing firms to produce the tires. After awhile, realizing that, merely as a selling concern, their position would be weakened by the expiration of their patents, they began to plan to become manufacturers, for which purpose they reserved a portion of their profits year by year, which was invested in a manufacturing plant. By the time the patents expired, therefore, in 1904, the Dunlop Rubber Co., Limited, their subsidiary manufacturing concern, had going at Birmingham an extensive plant, reputed to be producing more bicycle tires than any other factory in existence, besides which the company are producing motor tires on a large scale. The factory referred to was acquired from the firm of Byrne Brothers & Co., who had operated it for many years. The tire patents referred to as having expired are, of course, those relating to the form of the tire and means for retaining. The Dunlop interests still control the European rights under the Doughty patents for vulcanizing tires.

The Liverpool Rubber Co., Limited, at Liverpool, in successful operation since 1857, were active in the cycle tire trade from the beginning of the latter, and are now marketing motor tires as well.

The Leyland and Birmingham Rubber Co., Limited, are the result of the amalgamation, in 1898, of two factories and an important jobbing house of fifty years' standing, with a capitalization of £300,000 ($1,500,000). The company have a trade at home and abroad in all branches of their industry except rubber footwear and rubber thread, and have had a considerable share of the tire trade. The same interests control the Collier Tyre Co., Limited, and their factory at Leyland turns out the Collier tires.

The Sirdar Rubber Co., Limited, with a factory at Limpley Stoke, England, were formed originally to market a special bicycle tire. Their business has grown until they are now manufacturing all types of pneumatic and solid rubber tires, and have made a specialty of late of supplying tires for motor 'buses, such as are being run in London.

The Avon India-Rubber Co., Ltd., have a large plant in Melksham, Wiltshire, which they have operated since 1885. They are unique in one respect in that they have made and still make many single tube tires. Of course, they also make the double tube style, both for cycle and automobiles.

W. & A. Bates, Limited, in Leicester, general manufacturers of rubber goods, also make solid and pneumatic tires of all the leading

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types. Other concerns making tires are Wallington, Weston & Co., at Frome; St. Helens Cable and Rubber Co., Limited, at West Drayton (making solids of a special compound); The Midland Rubber Co., Limited, at Birmingham (controlled by the Dunlop company); and F. Reddaway & Co., Limited, at Manchester.

The manufacture of solid rubber tires for carriages is very important in Great Britain, and it is of interest to note the large share of this trade held by The Shrewsbury & Challiner Tyre Co., Limited, with offices in London and a factory at Manchester, especially as this firm was so intimately connected in the first introduction, on a large scale, of the solid rubber tire in practical use.

HOLLAND.

Bakker & Zoon, at Ridderkerk, extensive manufacturers of rubber goods, are producers of pneumatic and other rubber tires. The Liége house of Englebert has a branch factory at Bussum, near Amsterdam, and Augustinus & Witteveen, of Amsterdam, are manufacturers.

ITALY.

Pirelli & Co., established at Milan since 1872, have built up a rubber manufacturing business which ranks among the most important in Europe. From the beginning of the demand for pneumatic tires they were in a position to supply them, but in 1905 the matter of developing their automobile tire department was taken up with increased thoroughness and a branch factory built for it. The automobile industry in Italy is very important, affording a good market at home for tires. In addition to their own pneumatic tires, the Pirelli works manufacture the "Tenax" cushion tire for a company formed to exploit it in Italy; the same tire is known in France by the name of the patentee, Ducasble.

RUSSIA.

Two of the rubber goods factories in Russia are among the largest in Europe. Their output is most largely of rubber boots and shoes, a demand for which is created by the great amount of snow which falls there, though whatever other kinds of rubber goods are required in the empire are made also, including pneumatic and solid tires. The two companies referred to are the Russian-American India-Rubber Co., at St. Petersburg, and the Russian-French Rubber Works, "Prowodnik," at Riga.

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SWITZERLAND.

The making of tires has been taken on of late by R. & E. Huber, who have been established since 1895 as rubber manufacturers at Pfäffikon, near Zurich.

The growth of the tire industry is so great and constant that this brief record, doubtless, will soon be very inadequate. As the proofs of this book are being read six new companies are in sight in the United States alone, and who can predict what the certainly great increase both in companies and product will be in the next five or ten years?

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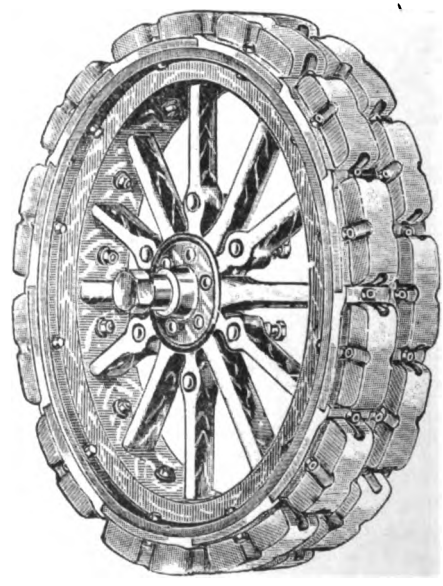

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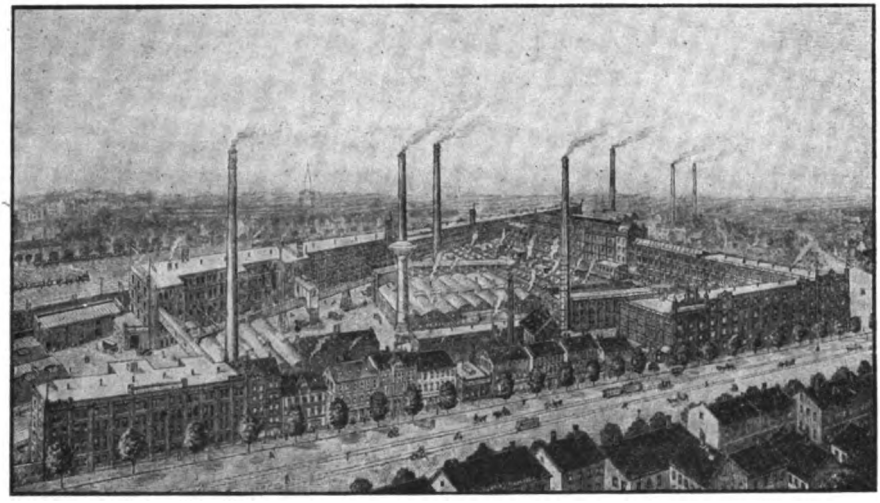

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